Sampling and Quality Assurance Project Plan Bremerton Gasworks Targeted Brownfields Assessment Bremerton, Washington

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SAMPLING AND QUALITY ASSURANCE PLAN FOR:

Bremerton Gasworks Targeted Brownfields Assessment
Bremerton, Washington

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List of Abbreviations and Acronyms

Acronym	Definition
amsl	above mean sea level
AST	Aboveground storage tank
bgs	Below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
EPA	Environmental Protection Agency
FID/PID	Flame Ionization Detector/Photo Ionization Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GPS	Global Positioning System
HPLC	High-Performance Liquid Chromatography
LCS	Laboratory Control Samples
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTCA	Model Toxics Control Act
MW	Monitoring Well
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PM	Project Manager
QA	Quality Assurance
QAPP	Quality Assuarance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RI/FS	Remedial Investigation/Fesiability Study
RPD	Relative Percent Difference
SHSP	Site Health and Safety Plan
SOP	Standard Operating Procedure
SQAP	Sample Quality Assurance Plan
TAL	Target Analyte List
TBA	Targeted Brownfields Assessment
TDD	Technical Direction Document
TEQ	Toxicity Equivalent
TM	Task Monitor
TPH	Total Petroleum Hydrocarbons
VCP	Voluntary Cleanup Program
VOC	Volatile Organic Compound

1 Project Management

Pursuant to the United States Environmental Protection Agency (EPA) Region 10 START-3 Contract Number EP-S7-06-02 and Technical Direction Document (TDD) number 07-05-0002, Ecology and Environment, Inc. (E & E) will perform a Targeted Brownfields Assessment (TBA) at the Bremerton Gasworks site, which is located in Bremerton, Washington. The EPA's Brownfields Economic Redevelopment Initiative is designed to empower states, cities, tribes, communities, and other stakeholders to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse Brownfields sites (EPA 2000). This Sampling and Quality Assurance Plan (SQAP) was prepared by E & E to support this project.

EPA order 5360.1, Change 1, Policy and Program Requirements for the Mandatory Agency-Wide Quality System (EPA 1988b) requires that all environmental data collection activities that are performed by or on behalf of the EPA be supported by an approved SQAP prior to the start of data collection activities. This SQAP was prepared in accordance with the EPA guidance documents QA/R-5, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, Final* (EPA 1988a). This SQAP details the quality assurance (QA) and quality control (QC) procedures and data collection activities (field sampling tasks) for the TBA at the Bremerton Gasworks TBA site. The SQAP, the site health and safety plan (SHSP), and standard operating procedures (SOPs) collectively form the set of plans for this project.

The purpose of this project is to provide the City of Bremerton and the owners of the properties with a limited assessment to provide additional analytical data of contamination onsite. This assessment will involve the sampling of specific areas of concern within the study area. This assessment will also provide an overview of recommended cleanup options and estimates of relative costs, should they be required.

The level of detail and the QA/QC specified in the project plans are based on the scope of work, cost, technical requirements, project-specific conditions, and the intended use of the data. EPA QA/R-5 requires that a SQAP address 24 topics or elements in four subject areas. The elements contained in this SQAP are grouped to reflect the following general processes:

- Project Administration (Section 2);
- Measurement/Data Acquisition (Section 3);
- Assessment/Oversight (Section 4); and
- Data Validation and Usability (Section 5).

2 Project Administration

2.1 Project/Task Organization (Element A4)

This section outlines the individuals directly involved with the Bremerton Gasworks TBA project and their specific responsibilities. Lines of communication are shown in the Project Organization Chart (Figure 2-1).

2.1.1 EPA Task Monitor

The Task Monitor (TM) is the overall coordinator of the project and decision maker. The TM reviews and approves the site-specific SQAP and subsequent revisions in terms of project scope, objectives, and schedules. The TM ensures site-specific SQAP implementation. The TM is the primary point of contact for general project problem resolution and has approving authority for the project.

2.1.2 EPA Quality Assurance Officer

The EPA Quality Assurance Officer (QAO) reviews and approves the site-specific SQAP and revisions in terms of QA aspects. The EPA QAO may conduct assessments of field activities.

2.1.3 E & E Project Manager

The E & E Project Manager (PM) provides overall coordination of the field work. The E & E PM provides oversight during the preparation of the site-specific SQAP. The E & E PM implements the final approved version of the site-specific SQAP and records any deviations. The E & E PM acts as the primary contact point with the EPA TM. The E & E PM receives Contract Laboratory Program (CLP)/Region 10 Manchester Environmental Laboratory (MEL) information from the EPA Regional Sample Control Coordinator (RSCC). The E & E PM acts as the primary START point of contact for technical problems. The E & E PM is responsible for the execution of decisions and courses of action deemed appropriate by the TM. In the absence of the START PM, a START Site Manager will assume the PM's responsibilities.

2.1.4 E & E Quality Assurance Officer

The E & E QAO reviews and approves the site-specific SQAP. The E & E QAO conducts in-house audits of field operations. The E & E QAO is responsible for auditing and reviewing the field activities and final deliverables and proposing corrective action, if necessary, for nonconformities.

2.1.5 EPA Regional Sample Control Coordinator

The EPA RSCC coordinates sample analyses performed through the EPA CLP and/or the EPA MEL and provides sample identification numbers.

2.2 Problem/Definition (Element A5)

2.2.1 Site Summary

The Bremerton Gasworks site is located on two adjacent properties covering approximately 3.68 acres in the city of Bremerton, Kitsap County, Washington (Figure 2-2). The site is comprised of tax parcel numbers 3711-000-001-0409 and 3711-00-001-0607 (McConkey parcels) and tax parcel number 3711-000-022-0101 (Sesko parcel). The site is located at 1725 Pennsylvania Avenue approximately one mile north by northwest of downtown Bremerton (Figure 2-3; Geoengineers 2007).

The McConkey properties cover approximately 3.13 acres. The Sesko property covers approximately 0.55 acres (TechLaw 2006). The McConkey properties have multiple warehouse buildings that are leased for various small businesses, which include marine and storage services. The Sesko property is currently vacant. The only structures on this property are the former foundations of the aboveground storage tank (AST) farm (TechLaw 2006).

The site is situated in mixed use commercial, industrial, and residential area. The site is bordered to the north by the Washington Narrows waterway, South McConkey Industrial Park to the south, Thompson Avenue to the west, and Pennsylvania Avenue to the east.

The McConkey Properties are operated by Trip McConkey as a mixed use commercial property. Past commercial uses included sheet metal fabrication, drum storage facilities, automotive and marine repair, metal salvage yard, painting/sandblasting activities, and petroleum bulk storage and distribution. The McConkey properties currently have five separate buildings, which are leased to a metal fabrication shop, piston ring shop, granite countertop workshop, and a welding shop (TechLaw 2006).

The Sesko property is owned by Natasha Sesko, but the property appears to be vacant. This property has unpaved road access to the Washington Narrows beachfront. It is believed that the site was formely used as temporary storage for heavy equipment, according to Trip McConkey (McConkey 2007).

A bulk petroleum storage facility (ARCO) was previously located northwest of the McConkey Properties. Currently, SC Fuels, a petroleum bulk storage facility, is located east of Pennsylvania Avenue.

The site was originally developed by the Western Gas and Utilities Corporation to provide the city of Bremerton with light, heat, and electricity by natural gas. The former gasification physical plant, boiler, and aboveground storage tanks apparently were removed between 1985 and 1993 based on aerial photographs (TechLaw 2006). The gasification plant was in operation from approximately 1930 to 1956. The plant was fueled by shipments of coal, delivered by boat. The gasification process may have started by processing the coal with high temperature and pressure, using boiler plant steam and measured amounts of oxygen. The final gas product (coal or natural gas) was sent by pipeline to local residences in Bremerton (TechLaw 2006).

This site also was utilized for petroleum storage and distribution from approximately 1963 to 1985. Petroleum products were stored in ASTs and distributed by underground pipeline. It is unknown how many of the underground fuel distribution lines were removed, if product remains in the lines, or if the distribution lines remain underground (TechLaw 2006).

Groundwater is located at depths ranging from 15 to 35 feet below ground surface (bgs). It is not clear if shallow groundwater at the site is influenced by tidal variations from the Washington Narrows. Groundwater follows a slight north-northwest gradient towards the Washington Narrows. (Geoengineers 2007).

2.2.2 Projected/Planned Site Uses

The City of Bremerton and Trip McConkey propose to develop the properties into a multipurpose commercial marine area. This area would include a public access marina, commercial businesses, and the potential of condominium housing. The City of Bremerton was the recipient of an EPA Brownfields Assessment Grant (BF-9604651-0) in 2006. This grant provides funding for assessment of contamination on site (Geonengineers 2007). This site may enter into the Washington State Department of Ecology Voluntary Cleanup Program (VCP) pending results from the EPA TBA and GeoEngineers' RI/FS.

2.2.3 Previous Investigations

In November 2006, a Phase I TBA was conducted at the site by TechLaw, Inc. for EPA Region 10 Superfund. The purpose of the assessment was to identify environmental issues that might require remediation before redevelopment occurs. The Phase I ESA was conducted in general accordance with ASTM E 1527-05. The report details site conditions and those of nearby or adjacent properties that could have a negative environmental influence on the site. The report indicates that in addition to use as a coal gasification plant and petroleum distributor, the property was used by an electroplating shop. Based on the Phase I ESA, the following suspected or known recognized environmental conditions were identified:

- A high potential for petroleum contaminated soil from the former coal gasification facility, petroleum distribution activities, and other unknown activities;
- A high potential for coal pitch volatiles contaminating soil from the former coal gasification facility and potential ash deposits from the former boiler

plant , which may contain polynuclear aromatic hydrocarbons (PAHs) or semivolatile organic compounds (SVOCs), and

- A high potential for petroleum and PAH contaminated groundwater beneath the site. The petroleum groundwater contamination was suspected to be present either due to past site activities or to migration from groundwater contamination at a nearby current (SC Fuels) and former (ARCO) petroleum distribution facilities (TechLaw 2006).

In 2007, the City of Bremerton contracted Geoengineers to conduct an assessment of the uplands of the site. This work included the construction of eight groundwater monitoring wells (MW-1 through MW-8), collection of subsurface soil samples and collection of groundwater samples to determine if contamination is present at the site (Figure 2-3). Soil samples were analyzed for: petroleum hydrocarbons, volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), metals, and PAHs. Groundwater samples were analyzed for: were: petroleum hydrocarbons, SVOCs, VOCs, PCBs, metals, and PAHs. Analytical results were compared to Washington State Model Toxics Control Act (MTCA) Method A soil screening standards for unrestricted land use established under WAC 173-340-740 (2). If no Method A value was available, MTCA Method B soil screening standards for unrestricted land use established under WAC 173-340-740 (2) were used. A summary of analytical results is provided below:

- Monitoring well MW-1 was located near the metal fabrication building in the Middle McConkey property (Figure 2-3). Two subsurface soil samples were collected from this location at 5 feet and 35 feet bgs. Subsurface soil sample results did not indicate the presence of any analytes at levels that exceeded the MTCA Method A screening value. The top of the casing was measured at 45.03 feet above mean sea level (amsl) and depth to groundwater at this well was 34.68 feet bgs. Groundwater analytical results indicated the presence of carbon tetrachloride at levels that exceeded MTCA Method B screening levels.
- Monitoring well MW-2 was located near the welding shop. Two subsurface soil samples were collected from 10 and 40 feet bgs. Subsurface soil sample results indicated the presence of naphthalenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene at concentrations that exceeded the MTCA Method A screening levels. The top of the well casing was measured at 42.54 feet amsl and depth to groundwater at this well was 35.25 feet bgs. Analytical results for groundwater samples were above MTCA Method A screening levels for benzene.
- Monitoring well MW-3 was located near the south edge of the north McConkey property (Figure 2-3). Two subsurface soil samples were collected from 5 to 25 feet bgs. Analytical results for subsurface soil samples were above MTCA Method A screening levels for: petroleum hydrocarbons, benzene, naphthalene, arsenic, naphthalenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The top of the casing was

measured at 39.10 feet amsl and depth to groundwater at this well was 32.90 feet bgs. Analytical results for groundwater samples were above MTCA Method A screening levels for: gasoline-range and diesel-range hydrocarbons, arsenic, chromium, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

- Monitoring well MW-4 was located near the center of the Sesko property (Figure 2-3). Two subsurface soil samples were collected from 15 to 30 feet bgs. Analytical results for subsurface soil samples were above MTCA Method A screening levels for: gasoline-range and diesel-range hydrocarbons, naphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The top of the casing was measured at 35.20 feet amsl and depth to groundwater at this well was 29.32 feet bgs. Analytical results for groundwater were above MTCA Method A screening levels for: gasoline–range and diesel-range hydrocarbons, acenaphthene, benzene, naphthalene, arsenic, chromium, lead, benzo(a)-anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
- Monitoring well MW-5 was located on the Sesko beach access road (Figure 2-3). Two subsurface soil samples were collected from 10 to 20 feet bgs. Analytical results for subsurface soil samples were above MTCA Method A screening levels for: benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The top of the casing was measured at 18.51 feet amsl and depth to groundwater at this well was 15.21 feet bgs. Analytical results for groundwater samples were above MTCA Method A screening levels for: benzene, chromium VI, benzo(a)-anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
- Monitoring well MW-6 was located on the North McConkey property, near the center of the property in the center of the former gasworks gas holder column (Figure 2-3). Three subsurface soil samples were collected from 5, 10, and 35 feet bgs. Analytical results for subsurface soil samples were above MTCA Method A screening levels for: gasoline-range and diesel-range hydrocarbons, naphthalene, total xylenes, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The top of the casing was measured at 34.95 feet amsl and depth to groundwater at this well was 30.20 feet bgs. Analytical results for groundwater samples were above MTCA Method A screening levels for: gasoline-range and diesel-range hydrocarbons, benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)-anthracene, and indeno(1,2,3-cd)pyrene.
- Monitoring well MW-7 was located on the northwest corner of the North McConkey property (Figure 2-3). Two subsurface soil samples were collected

from 5 to 25 feet bgs. Analytical results for subsurface soil samples were above MTCA Method A screening levels for: gasoline–range and diesel-range hydrocarbons, naphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The top of the casing was measured at 33.24 feet amsl and depth to groundwater at this well was 30.21 feet bgs. Analytical results for groundwater samples were above MTCA Method A screening levels for: benzo(a)anthracene, benzo(a)pyrene, and benzo(k)fluoranthene.

- Monitoring well MW-8 was located on the northeast corner of the North McConkey property (Figure 2-3). Two subsurface samples were collected from 10 to 25 feet bgs. Analytical results for subsurface soil samples were above MTCA Method A screening levels for: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The top of the casing was measured at 35.56 feet amsl and depth to groundwater at this well was 32.64 feet bgs. Analytical results for groundwater samples were above MTCA Method A screening levels for: gasoline–range and diesel-range hydrocarbons, benzene, naphthalene, chromium VI, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
- Groundwater results indicated that petroleum hydrocarbons, SVOCs, VOCs, PAHs and TAL metals were detected at concentrations that exceed MTCA Method A (or B) screening levels in at least one of the eight wells (GeoEngineers 2007).

2.3 Regulatory Standards

Analytical results from this TBA for soil at the site will be compared to MTCA Method A soil screening standards for unrestricted land use established under WAC 173-340-740 (2). If no Method A value is available, standard U.S. EPA Region 6 Human Health Medium-Specific Screening Levels will be used. Table 2-1 provides MTCA Method A and U.S. EPA Region 6 Human Health Medium-Specific Screen Levels soil screening standards.

Analytical results from this TBA for groundwater at the site will be compared to MTCA Method A groundwater screening standards. If no Method A value is available, U.S. EPA Region 6 Human Health Medium-Specific Screening Levels will be used. Table 2-2 provides MTCA Method A and U.S. EPA Region 6 Human Health Medium-Specific Screening Levels groundwater cleanup standards.

2.4 Schedule (Element A6)

The schedule for implementing the Bremerton Gasworks TBA is intended to be used as a guide. Adjustments to the implementation dates and the estimated project duration may be necessary to account for variable unforeseen or unavoidable conditions that the field team may encounter. Examples include inclement weather, difficulties in accessing a sampling site, unforeseen site conditions, or additional time needed to complete a task. Significant schedule changes that arise in the field will be discussed with the TM at the earliest possible opportunity.

The START-3 is targeting March 17, 2008, as the earliest period to conduct the TBA field work. The field work is estimated to take 6 days, including travel time to and from the site. This period comprises 0.5 day of mobilization, 0.5 day of demobilization, and 5 days to complete field activities. Work will be conducted during daylight hours only. Table 2-3 presents the proposed schedule of project work:

2.5 Quality Objectives and Criteria for Measurement Data (Element A7)

It is the goal of the EPA and the regulated community to collect data of sufficient quantity and quality to support defensible decisions. At the same time, it is necessary to minimize expenditures related to data collection by eliminating unnecessary, duplicative, or overly precise data. The most efficient way to accomplish both of these goals is to begin each project by defining project data quality objectives (DQOs) and measurement performance criteria. The QA requirements, identified as a result of the DQO projects, will be used at three stages in the project:

- At project inception, to present the plans for project execution from a QA viewpoint, including the type and quality of environmental data to be collected;
- During the project, to act as a guide for QA implementation, review, and audits, and to serve as the specifications for assessing the quality of data generated; and
- At project completion, to serve as a basis for determining whether the project has attained the established goals.

The project-specific quality objective for the Bremerton Gasworks TBA site is to acquire data that can reliably be used to make decisions regarding the presence of on-site contamination related to former operations. To obtain data that will support this decision, the following quality controls will be applied:

- Laboratories will provide definitive data. The data will be reviewed and assessed for the five data assessment parameters described in subsections 2.5.1 through 2.5.5. Field QC samples will include trip blank and equipment rinsate samples. Laboratory QC samples will include surrogates, laboratory spikes and duplicates, and laboratory blanks. Both field and laboratory QC will be evaluated.
- Field QC samples (trip blank and rinsate samples) will be collected and analyzed in the same manner as all environmental samples (see subsection 3.5.1).
- Laboratory QC samples (blanks, surrogates, duplicates, and spikes) will be analyzed to assess laboratory performance (see subsection 3.5.2).

This subsection presents data assessment parameters that have been identified by the EPA: precision, accuracy, completeness, comparability, and representativeness. The quantitative quality criteria/indicators for three of the five project data assessment parameters (precision, accuracy, and completeness) have been determined for this project through the use of the DQO process and are presented in Section 3 along with the analytical reporting limits required to meet the project goals.

At project completion, data will be compared with stated objectives for precision (determination of analytical and/or total measurement error), accuracy, and completeness, as well as the actual method reporting limits. A detailed data validation effort will not be completed for this project; a limited data quality assessment will be performed on the unvalidated data. The five data assessment parameters are described in the following subsections.

2.5.1 Precision

Precision is a measure of mutual agreement among replicated (or between duplicate) or collocated sample measurements of the same analyte. The closer the numerical values to the measurements are to each other, the more precise the measurement. Precision is determined through calculation of analytical and/or total measurement error.

2.5.2 Accuracy

Accuracy is a measure of bias in a measurement system. The closer the value of the measurement agrees with the true value, the more accurate the measurement. Accuracy is expressed as the percent recovery of the surrogate or spike analyte from a sample or standard. Accuracy is dependent on traceability of instrumentation, standards, samples, and data methodology; blanks; surrogates; reference or spiked samples; performance samples; and equipment calibration

2.5.3 Completeness

Completeness is a measure of the number of valid measurements obtained in relation to the total number of measurements planned. The closer the numbers are, the more complete the measurement process. Completeness is expressed as the percentage of planned measurements that are valid. A sufficient volume of sample material is collected to complete the required the required analyses so that samples represent all possible contaminant situations under investigation, as well as background and control areas. Completeness is influenced by environmental conditions, potential for change with respect to time and location, equipment maintenance, data records, sampling location, sample volume, QC samples, and sample representativeness.

2.5.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. The comparability goal is achieved through the use of SOPs to collect and analyze representative samples, and reporting of analytical results in appropriate and consistent units and reporting limits. The goal is also achieved by maintaining consistency in sampling conditions, selection of sampling procedures, sample preservation methods, and analytical methods.

2.5.5 Representativeness

Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. The design and rationale for the sampling program ensure that environmental conditions have been sufficiently represented. The design and rationale include the purpose of sampling, the selection of sampling locations, the number of samples to be collected, the ambient conditions for sample collection, the frequencies and timing for sampling, and the sampling techniques. Representativeness is evaluated, in part, by examining the chain-of-custody paperwork and verifying that the sample analyses were performed within the holding time.

2.6 Special Training/Certification (Element A8)

Special training requirements or certifications, such as the 40-hour Hazardous Waste Operations class and annual refreshers, are required for all field activities. Health and safety procedures for E & E personnel are addressed in the E & E SHSP.

2.7 Documents and Records (Element A9)

This document is meant to be combined with the information presented in E & E's *Quality Assurance Project Plan* (QAPP; E & E 2005b) for Region 10 START-3. This information is covered by the SOPs found in Appendix A and the CLP Laboratory Statements of Work. A copy of the START-3 QAPP is available in E & E's Seattle, Washington office. Standards contained in the SOPs, the START-3 QAPP and Quality Management Plan (QMP) will be used to ensure the validity of data generated by E & E for this project.

Following the completion of fieldwork and the receipt of analytical data, a report will be prepared that summarizes project findings. Project files include work plans, reports, analytical data packages, correspondence, chain-of-custody documentation, logbooks, and corrective action forms. Referenced materials and photographs will be provided to the EPA TM at the close of the project.

Table 2-1 MTCA Soil Screening Standards (mg/kg)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
Total Petroleum Hydrocarbons		
TPH, diesel range organics	2000	N/A
TPH: gasoline range organics, benzene present	30	N/A
TPH: gasoline range organics, no detectable benzene	100	N/A
Target Analyte List (TAL) Metals		
Aluminum	N/A	76000
Antimony	N/A	31
Arsenic	20	22
Barium	N/A	5400
Beryllium	N/A	150
Cadmium	2	37
Calcium	N/A	N/A
Chromium	N/A	210
Cobalt	N/A	900
Copper	N/A	3100
Iron	N/A	23000
Lead	250	400
Magnesium	N/A	N/A
Manganese	N/A	1800
Mercury	2	23
Nickel	N/A	1600
Potassium	N/A	NA
Selenium	N/A	390
Silver	N/A	390
Thallium	N/A	5.2
Vanadium	N/A	550
Zinc	N/A	23000
Cyanide	N/A	1200
Semi-Volatile Organic Compounds (SVOCs)		
Acenaphthene	N/A	3700
Aniline	N/A	850
Anthracene	N/A	22000
Benzidine	N/A	.0005

Table 2-1 MTCA Soil Screening Standards (mg/kg)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
Benzo[a]anthracene	N/A	0.15
Benzo[a]pyrene	0.1	0.15
Benzo[b]fluoranthene	N/A	0.15
Benzo[k]fluoranthene	N/A	0.15
Benzoic acid	N/A	10000
Benzyl alcohol	N/A	18000
bis(2-chloroethyl)ether	N/A	.21
bis(2-chloroisopropyl) ether	N/A	2.9
bis(2-ethylhexyl) phthalate	N/A	35
Butyl benzyl phthalate	N/A	240
Caprolactam	N/A	31000
Carbazole	N/A	240
Chlorophenol;2-	N/A	640
Chrysene	N/A	15
Dibenzo[a,h]anthracene	N/A	0.15
Dibenzofuran	N/A	150
Dichlorobenzene;1,2-	N/A	2800
Dichlorobenzene;1,4-	N/A	3.2
Dichlorobenzidine;3,3'-	N/A	1.1
Dichlorophenol;2,4-	N/A	180
Dimethyl phthalate	N/A	10000
Dimethylphenol;2,4-	N/A	1200
Dinitrophenol;2,4-	N/A	120
Dinitrotoluene;2,4-	N/A	120
Dinitrotoluene;2,6-	N/A	61
Di-n-octyl phthalate	N/A	N/A
Fluoranthene	N/A	2300
Fluorene	N/A	2600
Hexachlorobenzene	N/A	0.30
Hexachlorobutadiene	N/A	6.2
Hexachlorocyclopentadiene	N/A	3700
Hexachloroethane	N/A	35
Indeno[1,2,3-cd]pyrene	N/A	0.15
Isophorone	N/A	510
Naphthalene	5	120

Table 2-1 MTCA Soil Screening Standards (mg/kg)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
Nitroaniline, 2-	N/A	180
Nitrobenzene	N/A	20
Nitroso-di-n-propylamine;N-	N/A	0.069
Nitrosodiphenylamine;N-	N/A	99
Pentachlorophenol	N/A	3.0
Phenol	N/A	18000
Pyrene	N/A	2300
Trichlorobenzene;1,2,4-	N/A	140
Trichlorophenol;2,4,5-	N/A	6100
Trichlorophenol;2,4,6-	N/A	44
Volatile Organic Compounds (VOCs)		
acetone	N/A	1400
benzene	N/A	0.66
bromoform	N/A	62
bromomethane	N/A	3.9
carbon disulfide	N/A	720
carbon tetrachloride	N/A	0.24
chlorobenzene	N/A	320
chloroform	N/A	0.25
chloromethane	N/A	1.3
dibromo-3-chloropropane;1,2-	N/A	0.45
Dibromochloromethane	N/A	1
dichlorobenzene;1,2-	N/A	280
dichlorobenzene;1,4-	N/A	3.2
dichlorodifluoromethane	N/A	94
dichloroethane;1,1-	N/A	850
dichloroethane;1,2-	N/A	0.35
dichloropropane;1,2-	N/A	0.35
ethylbenzene	6	230
hexachlorobutadiene	N/A	6.2
hexachloroethane	N/A	35
methylene chloride	0.02	8.9
naphthalene	5	120
styrene	N/A	1700
tetrachloroethane;1,1,1,2-	N/A	1400

Table 2-1 MTCA Soil Screening Standards (mg/kg)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
tetrachloroethane;1,1,2,2-	N/A	0.84
tetrachloroethylene	0.05	0.55
toluene	7	520
tribromobenzene;1,2,4-	N/A	310
trichloroethane;1,1,1-	2	1400
trichloroethane;1,1,2-	N/A	N/A
trichloroethylene	0.03	0.84
trichloropropane;1,2,3-	N/A	0.0014
trimethylbenzene;1,2,4-	N/A	52
trimethylbenzene;1,3,5-	N/A	21
vinyl chloride	N/A	0.043
xylene;m-	N/A	210
xylene;o-	N/A	280

Key:
µg/L = micrograms per liter
N/A = not available
TPH = total petroleum hydrocarbon
VOCs = volatile organic compounds

Table 2-2 MTCA Groundwater Screening Standards (µg/L)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
Total Petroleum Hydrocarbons		
TPH, diesel range organics	500	N/A
TPH: gasoline range organics, benzene present	800	N/A
TPH: gasoline range organics, no detectable benzene	1000	N/A
Target Analyte List (TAL) Metals		
Aluminum	N/A	36500
Antimony	N/A	15
Arsenic	5	0.045*
Barium	N/A	7300
Beryllium	N/A	73
Cadmium	5	18
Calcium	N/A	N/A
Chromium	50	N/A
Cobalt	N/A	730
Copper	N/A	1400
Iron	N/A	26000
Lead	15	15
Magnesium	N/A	N/A
Manganese	N/A	1700
Mercury	2	11
Nickel	N/A	730
Potassium	N/A	N/A
Selenium	N/A	180
Silver	N/A	180
Thallium	N/A	2.6
Vanadium	N/A	180
Zinc	N/A	11000
Cyanide	N/A	730
Semi-Volatile Organic Compounds (SVOCs)		
1,3,5-Trimethylbenzene	N/A	21
2,4-dimethylphenol	N/A	730
2-methylphenol	N/A	1800
4-methylphenol	N/A	180
Acenaphthene	N/A	370

Table 2-2 MTCA Groundwater Screening Standards (μg/L)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
Acenaphthylene	N/A	N/A
Anthracene	N/A	1800
Benz(a)anthracene	N/A	0.029
Benzo(a)pyrene	0.1	0.0029
Benzo(b)fluoranthene	N/A	0.029
Benzo(g,h,i)perylene	N/A	.29
Benzo(k)fluoranthene	N/A	.29
Benzoic acid	N/A	.000015
benzyl alcohol	N/A	.00011
Bis(2-ethylhexyl)phthalate (DEHP)	N/A	4.8
Butyl Benzyl Phthalate	N/A	7300
Chrysene	N/A	2.9
Dibenzo(a,h)anthracene	N/A	.0029
Dibenzofuran	N/A	12
Diethyl phthalate	N/A	29000
Dimethyl phthalate	N/A	.000037
Di-n-butyl phthalate	N/A	N/A
Di-n-Octyl phthalate	N/A	N/A
Fluoranthene	N/A	1500
Fluorene	N/A	240
Hexachlorobenzene	N/A	.042
Hexachlorobutadiene	N/A	.86
Hexachloroethane	N/A	4.8
Indeno(1,2,3-cd)pyrene	N/A	0.029
Naphthalene	160	6.2
N-Nitrosodiphenylamine	N/A	14
Pentachlorophenol	N/A	0.56
Phenanthrene	N/A	N/A
Phenol	N/A	11000
Pyrene	N/A	180
Volatile Organic Compounds (VOCs)		
acetone	N/A	5475
benzene	5	0.36
bromoform	N/A	8.5
bromomethane	N/A	8.7

Table 2-2 MTCA Groundwater Screening Standards (μg/L)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
carbon disulfide	N/A	1043
carbon tetrachloride	N/A	0.17
chlorobenzene	N/A	91
chloroform	N/A	0.17
chloromethane	N/A	188
dibromo-3-chloropropane;1,2-	N/A	0.0002
Dibromochloromethane	N/A	0.13
dichlorobenzene;1,2-	N/A	49
dichlorobenzene;1,4-	N/A	0.47
dichlorodifluoromethane	N/A	395
dichloroethane;1,1-	N/A	1217
dichloroethane;1,2-	5	0.12
dichloropropane;1,2-	N/A	0.16
ethylbenzene	700	1340
hexachlorobutadiene	N/A	0.86
hexachloroethane	N/A	4.8
methylene chloride	5	4.3
naphthalene	160	6.2
styrene	N/A	1641
tetrachloroethane;1,1,1,2-	N/A	0.43
tetrachloroethane;1,1,2,2-	N/A	0.055
tetrachloroethylene	5	0.1
toluene	1000	2281
tribromobenzene;1,2,4-	N/A	N/A
trichloroethane;1,1,1-	200	73000
trichloroethane;1,1,2-	N/A	0.2
trichloroethylene	5	0.028
trichloropropane;1,2,3-	N/A	0.034
trimethylbenzene;1,2,4-	N/A	12.5
trimethylbenzene;1,3,5-	N/A	12.3
vinyl chloride	0.2	0.015
xylene;m-	N/A	208
xylene;o-	N/A	73000

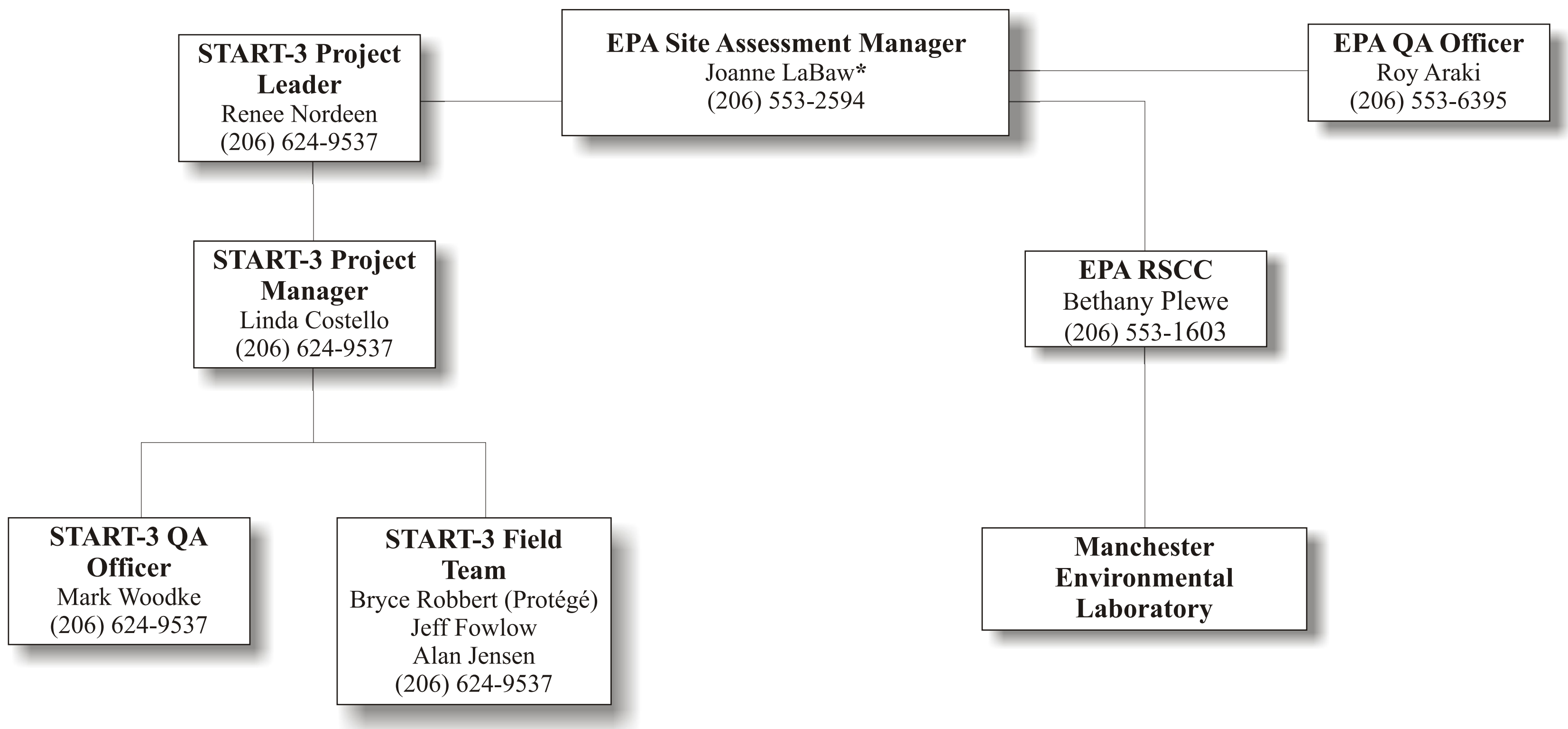
Key:
* = Cancer endpoint only.
μg/L = micrograms per liter

Table 2-2 MTCA Groundwater Screening Standards (μg/L)

Compound	Method A Unrestricted Land Use	Region 6 HHMSSL
N/A = not available TPH = total petroleum hydrocarbon VOCs = volatile organic compounds		

Table 2-3 Schedule

Activity	Start Date	Completion Date
Mobilize to the site	3/17/08	3/17/08
Sample collection activities	3/17/08	3/21/08
Laboratory receipt of samples	3/17/08	3/21/08
Demobilization from the site	3/21/08	3/21/08
Laboratory analysis	3/18/08	4/7/08
Data validation	4/8/08	4/23/08
Writing of the project report	3/21/08	5/30/08
Target project completion date	NA	6/30/08



KEY:

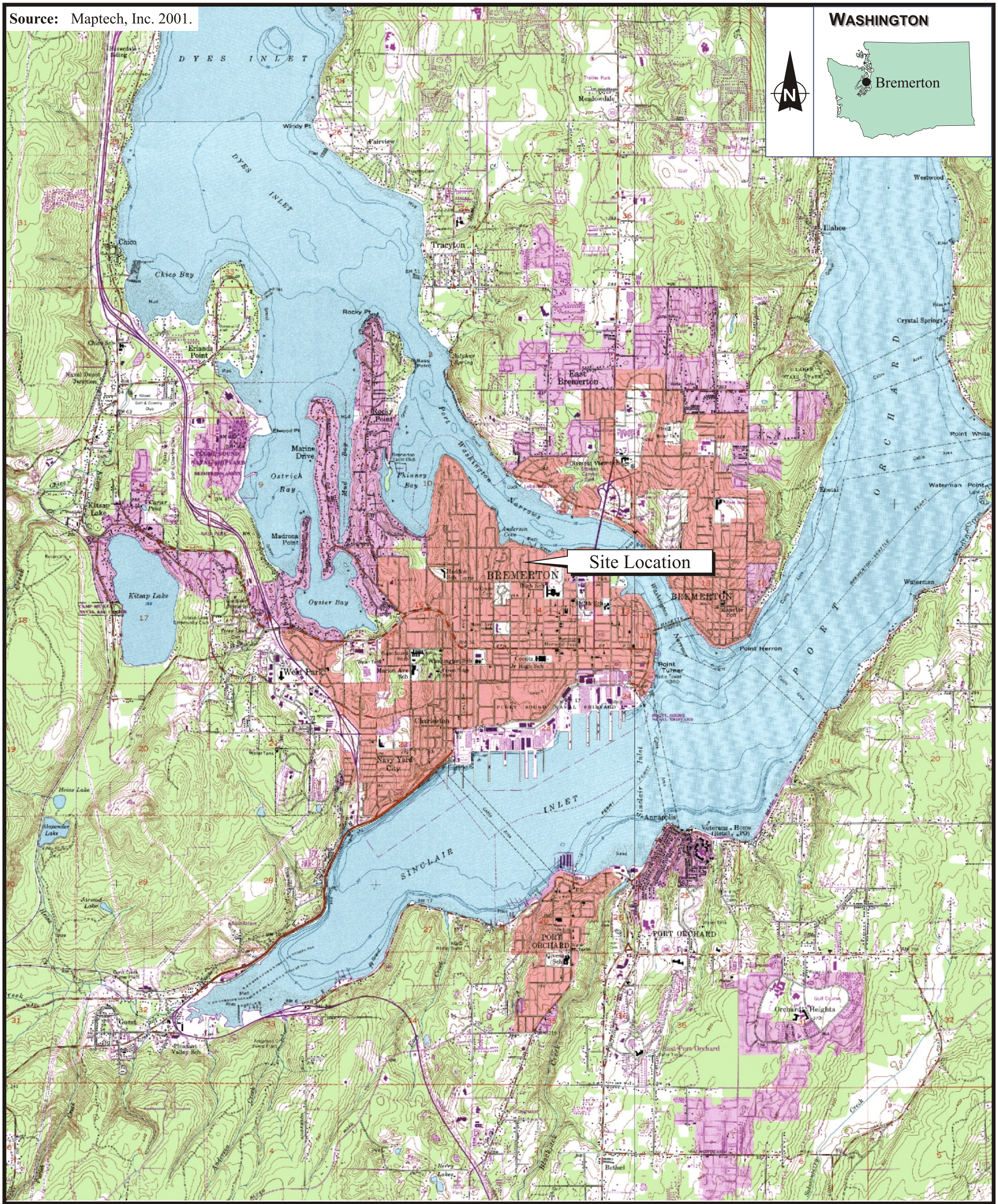
* Approving Authority

ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

BREMERTON GASWORKS TBA
Bremerton, Washington

Figure 2-1
PROJECT ORGANIZATION CHART

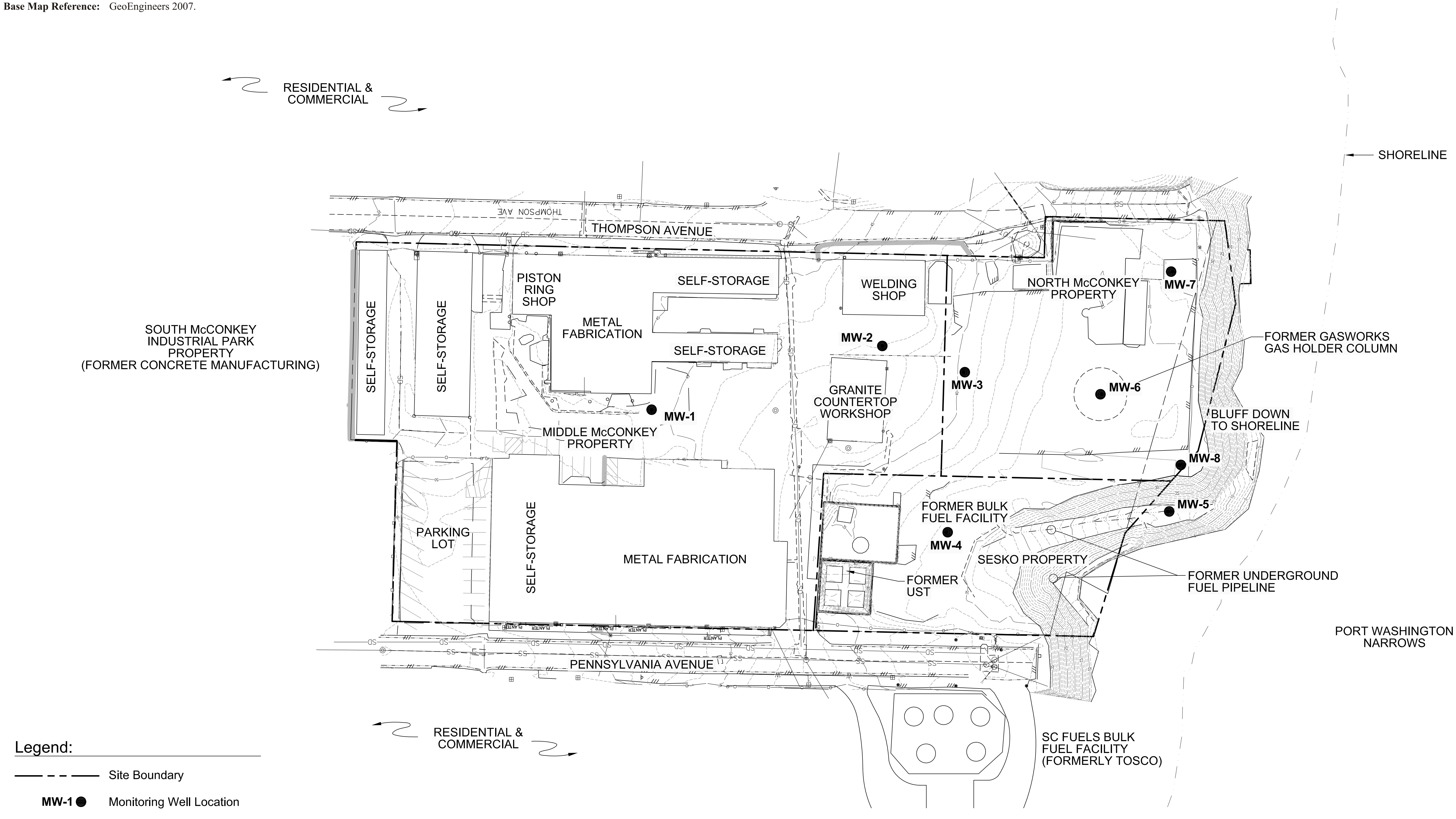
Date:	Drawn by:	
2/15/08	AES	10:START-3\07010008\fig 2-1



ecology and environment, inc. International Specialists in the Environment Seattle, Washington	BREMERTON GASWORKS TBA Bremerton, Washington	Figure 2-2 SITE VICINITY MAP

0 .5 1 Approximate Scale in Miles	Date: 2-15-08	Drawn by: AES	10:START-3\07010008\fig 2-2

Base Map Reference: GeoEngineers 2007.



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Seattle, Washington

0 70 140
Approximate Scale in Feet

BREMERTON GASWORKS TBA
Bremerton, Washington

Figure 2-3
GEOENGINEERS MONITORING WELL LOCATION MAP

Date:	Drawn by:	
2/15/08	AES	10:START-3\07010008\fig 2-3

3 Measurement/Data Acquisition

3.1 Sampling Process Design (Element B1)

A judgmental sampling design will be used for the Bremerton Gasworks TBA that will fulfill specific project objectives by collecting biased data required for preliminary site characterization. The following subsections describe the types of sampling, analysis, and measurements to be conducted. The data are classified as critical because they are required to achieve the project objectives. More detailed sample collection procedures are provided in subsection 3.2.

The purpose of this sampling is to determine the presence of contamination remaining in the areas of concern. This will involve collecting surface soil and groundwater samples. As discussed above in subsection 2.3, the analytical results will primarily be compared to MTCA Method A standards; U.S. EPA Human Health Medium-Specific Screening Levels will be used when no Method A standards exist. These comparisons will be used to evaluate the need for additional investigation of the potential source areas. Table 3-1 presents sample collection information.

3.2 Sampling Methods Requirements (Element B2)

A general description of the sampling methods to be used during the Bremerton Gasworks TBA field sampling event is provided below. Detailed SOPs are provided in Appendix A. Location data will be collected at each sample station using Global Positioning System (GPS) technology.

In the event that the field conditions require adjustments to the methods identified in this SQAP, the site manager will contact the TM for approval prior to deviating from this plan. The site manager will document any changes to the SQAP in a Sample Plan Alteration Form (Appendix B).

Table 3-2 lists the types of samples to be collected and the analyses to be applied. Table 3-3 identifies both environmental and QC samples to be collected and analyzed for soil and water. Each type of QC sample is described in detail in subsection 3.5 of this plan.

3.2.1 Subsurface Soil Sampling and Analysis

Subsurface soil sample locations are depicted on Figure 3-1. Soil samples will be collected in accordance with the SOP in Appendix A. The following soil samples will be collected:

- Seven boreholes will be placed with positions building on previous work conducted by Geoengineers (see Section 2). Boreholes will be sampled every 5 feet to approximately 30 feet bgs (42 total) using a hollow stem auger drill rig. Samples will be screened to document soil lithology, color, moisture content, and field-screened with a TVA-1000 flame ionization detector/photo ionization detector (FID/PID) for petroleum contamination. Collected material will be placed in a dedicated stainless steel bowl, thoroughly homogenized, and placed into a pre-labeled container. The VOC aliquot will be removed directly from the sampler prior to homogenization. Samples will be analyzed for total petroleum hydrocarbons (TPH) as gasoline, TPH as diesel, VOCs including benzene, toluene, ethylbenzene, and xylenes (BTEX), SVOCs including PAHs, and target analyte list (TAL) metals. Borehole locations will be placed as following information:
  - Sampling location MP01 will be placed near the northwest corner of the welding shop to determine if contamination previously observed in well MW-3 has migrated in this direction.
  - Sampling locations MP02 and MP03 will be placed near Thompson Avenue on the right-of-way. These locations were selected to determine if contamination was migrating from the former ARCO facility, which is located to the west, to the site.
  - Sampling location MP04 will be placed north of well MW-6 (located at the former gasworks gas holder column) and near the edge of bulkhead to determine if contamination found at MW-6 has migrated in this direction.
  - Sampling locations SP01 and SP02 will be placed to determine if contamination is present on the periphery of the Sesko property.
  - Sampling location SP03 will be placed to determine whether former USTs have resulted in contamination in this area.

3.2.2 Sediment Sampling

Sediment sample locations are depicted on Figure 3-1. Sediment samples will be collected in accordance with the SOP in Appendix A. The following sediment samples will be collected:

- Five sediment samples will be collected on the shoreline of the Washington Narrows adjacent to the site. Samples will be collected from 0 to 30 centimeters bgs from areas below the average low water mark. Collected material will be placed in a dedicated stainless steel bowl, thoroughly homogenized, and placed into a pre-labeled container. The VOC aliquot will be removed directly from the sampler prior to homogenization. Samples will be analyzed for TPH as gasoline, TPH as diesel, VOCs including BTEX, SVOCs including PAHs, and TAL metals. Sampling locations were selected to address concerns that contamination could be migrating off site and into Washington Narrows.

3.2.3 Groundwater Sampling

Groundwater sample locations are depicted on Figure 3-1. Groundwater samples will be collected in accordance with the SOP in Appendix A. The following groundwater samples will be collected:

■ One groundwater sample will be collected from each of the seven boreholes. These samples will be used to provide a more complete assessment of groundwater conditions at the site and to determine whether petroleum-contaminated groundwater from nearby facilities is affecting groundwater beneath the site. Groundwater samples will be collected using a hollow stem auger drill rig from the top of the groundwater table. A dedicated bailer will be used with a Grundfos pumping system to extract groundwater samples from boreholes drilled with the hollow stem auger drill rig. Dedicated Teflon tubing with a non-dedicated check valve will be used to collect the groundwater samples. The check valve will be decontaminated using the process outlined in subsection 3.2.3 below. Samples will be pumped directly into pre-labeled sample containers, and preserved as required. Samples will be analyzed for TPH as gasoline, TPH as diesel, VOCs including BTEX, SVOCs including PAHs, and TAL metals. Two boreholes (i.e., MP04 and SP02) will be completed as monitoring wells. There locations will help in assessing groundwater conditions along the waterfront boundary in the future.

3.2.3 Decontamination Procedures

To the greatest extent possible, disposable and/or dedicated personal protective and sampling equipment will be used to avoid cross-contamination. When required, decontamination will be conducted in a central location, upwind and away from suspected contaminant sources. All sampling equipment used to collect routine samples undergoing trace organic or inorganic constituent analyses will undergo the following procedures (as listed in Appendix A):

1. Clean with tap water and non-phosphate detergent using a brush if necessary to remove particulate matter and surface films.
2. Rinse thoroughly with tap water.
3. 10% nitric acid.
4. Rinse thoroughly with organic/analyte free water.
5. Use a solvent rinse.
6. Air dry the equipment completely.
7. Triple rinse with distilled/deionized water.

3.2.4 Investigation-Derived Waste

START field team members will make every effort to minimize the generation of investigation-derived waste throughout the field effort. Attempts will be made to evaporate wastewater from decontamination operations on site. Any wastewater that cannot be evaporated will be contained in 55-gallon drums, labeled, and disposed at an approved facility based on analytical results from matrix samples. Disposable personal protective clothing and sampling equipment generated during field activities will be rendered unusable by tearing (when appropriate), bagged in opaque plastic garbage bags, and disposed at the local municipal landfill.

3.2.5 Standard Operating Procedures

The START field team will utilize the following SOPs (Appendix A) while performing field activities:

- Field Activities Logbooks;
- Soil Sampling;
- Sediment Sampling;
- Groundwater Sampling;
- Geologic Logging; and
- Decontamination Procedures

3.3 Sample Handling and Custody Requirements (Element B3)

This subsection describes sample identification and chain-of-custody procedures that will be used for the Bremerton Gasworks TBA field activities. The purpose of these procedures is to ensure that the quality of samples is maintained during collection, transportation, storage, and analysis. All chain-of-custody requirements comply with E & E's SOPs for sample handling. All sample control and chain-of-custody procedures will follow the EPA's (1991) *User's Guide to the Contract Laboratory Program.*

Examples of sample documents used for custody purposes are provided in Appendix C and include the following:

- Sample identification numbers;
- Sample tags or labels;
- Custody seals;
- Chain-of-custody and traffic report records;
- Field logbooks;
- Sample collection forms;
- Analytical request forms; and
- Analytical records.

During the field effort, the site manager or delegate is responsible for maintaining an inventory of these sample documents. This inventory will be recorded in a cross-referenced matrix of the following:

- Sample location;
- Sample identification number;
- Analyses requested and request form number(s);
- Chain-of-custody record numbers;
- Bottle lot numbers; and
- Air bill numbers.

Brief descriptions of the major sample identification and documentation records and forms are provided below.

3.3.1 Sample Identification

All samples will be identified using the sample numbers assigned by the EPA RSCC. Each sample label will be affixed to the jar and covered with clear tape. A sample tracking record will be kept as each sample is collected. The following will be recorded: location, matrix, sample number, observations, and depth. In addition to the EPA-assigned sample number, samples will be tracked with a sample code system designed to allow easy reference to the sample's origin and type. The sample code key will not be provided to the laboratory. Table 3-4 summarizes sample tracking code and location.

3.3.1.1 Sample Tags and Labels

Sample tags attached to or fixed around the sample container will be used to identify all samples collected in the field. The sample tags will be placed on bottles so as not to obscure any QA/QC lot numbers on the bottles, and sample information will be printed legibly. Field identification will be sufficient to enable cross-reference with the project logbook. For chain-of-custody purposes, all QA/QC samples will be subject to the same custodial procedures and documentation as site samples.

To minimize handling of samples containers, labels will be completed before sample collection to the extent possible. In the field, the label will be filled out completely using waterproof ink, then attached firmly to the sample containers and protected with clear tape. The sample label will provide the following information:

- Sample number;
- Sample location number;
- Date and time of collection;
- Analysis required; and
- pH and preservative (when applicable).

3.3.1.2 Custody Seals

Custody seals are preprinted gel-type seals, designed to break into small pieces if the seals are disturbed. Sample shipping containers (e.g., coolers, drums, and cardboard boxes, as appropriate) will be sealed in as many places as necessary to ensure security. Seals will be signed and dated before use. Clear tape will be placed over the seals to ensure that the seals are not broken accidentally during shipment. Upon receipt at the laboratory, the custodian will check (and certify by completing the package receipt log) that seals on shipping containers are intact.

3.3.1.3 Chain-of-Custody and Traffic Reports

For samples to be analyzed at the EPA MEL or at a CLP laboratory, the chain-of-custody record, analyses required forms, and/or analytical traffic report forms will be completed as described in the EPA's (1991) *User's Guide to the Contract Laboratory Program*. The chain-of-custody record, analyses required forms, and analytical traffic reports will be completed fully at least in duplicate by the field technician designated by the site manager as responsible for sample shipment to the appropriate laboratory. Information specified on the chain-of-custody record will contain the same level of detail found in the site logbook, except that the on-site measurement data will not be recorded. The custody record will include the following information:

- Name and company or organization of the person collecting the samples;
- Date samples were collected;
- Type of sampling conducted (composite or grab);
- Sample number (using those assigned by the EPA RSCC);
- Location of sampling station (using the sample code system described in Table 3-4);
- Number and type of containers shipped;
- Analyses requested; and
- Signature of the person relinquishing samples to the transporter, with the date and time of transfer noted and signature of the designated sample custodian at the receiving facility.

If samples require rapid laboratory turnaround, the person completing the chain-of-custody record will note these or similar constraints in the remarks section of the custody record.

The relinquishing individual will record all shipping data (e.g., air bill number, organization, date, and time) on the original custody record, which will be transported with the samples to the laboratory and retained in the laboratory's file. Original and duplicate custody records, together with the air bill or delivery note, constitute a complete custody record. It is the site manager's responsibility to ensure that all records are consistent and that they become part of the permanent job file.

3.3.2 Field Logbooks and Data Forms

Field logbooks (or daily logs) and data forms are necessary to document daily activities and observations. Documentation will be sufficient to enable participants to reconstruct events that occurred during the project accurately and objectively at a later time. All daily logs will be kept in a bound notebook containing numbered pages. All entries will be made in waterproof ink, dated, and signed. No pages will be removed for any reason.

Minimum logbook content requirements are described in the E & E SOP entitled *Field Activities Logbook*, found in Appendix A. If corrections are necessary, these corrections will be made by drawing a single line through the original entry (so that the original entry is legible) and writing the corrected entry alongside the original entry. The correction will be initialed and dated. Corrected errors may require a footnote explaining the correction.

3.3.3 Photographs

Photographs will be taken as directed by the team leader. Documentation of a photograph is crucial to its validity as a representation of an existing situation. The following information will be noted in the project task log concerning photographs:

- Date, time, and location where photograph was taken;
- Photographer (initials);
- Weather conditions;
- Description of photograph taken;
- Reasons why photograph was taken;
- Sequential number of the photograph;
- Camera lens system used; and
- Direction photograph was taken.

3.3.4 Custody Procedures

The primary objective of chain-of-custody procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is in custody when it is:

- In someone's physical possession;
- In someone's view;
- Locked up; or
- Kept in a secured area that is restricted to authorized personnel.

3.3.4.1 Field Custody Procedures

The following guidance will be used to ensure proper control of samples while in the field:

- As few people as possible will handle the samples.
- Coolers or boxes containing cleaned bottles will be sealed with a custody tape seal during transport to the field or while in storage before use. Sample bottles from unsealed coolers or boxes that appear to have been tampered with will not be used.
- The sample collector will be responsible for the care and custody of collected samples until they are transferred to another person or dispatched properly under chain-of-custody rules.
- The sample collector will record sample data in the field logbook.
- The site team leader will determine whether proper custody procedures were followed during the fieldwork and will decide if additional samples are required.

When transferring custody (i.e., releasing samples to a shipping agent), the following will apply:

- The coolers in which the samples are packed will be sealed and accompanied by two copies of the chain-of-custody records. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the chain-of-custody record. This record will document sample custody transfer.

- Samples will be dispatched to the laboratory for analysis with separate chain-of-custody records accompanying each shipment. Shipping containers will be sealed with custody seals for shipment to the laboratory. The chain-of-custody records will be signed by the relinquishing individual, and the method of shipment, name of courier, and other pertinent information will be entered on the chain-of-custody record before placement in the shipping container.
- All shipments will be accompanied by chain-of-custody records identifying their contents. The original record will accompany the shipment. The other copies will be distributed appropriately to the site team leader and site manager.
- If sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation.

3.3.4.2 Laboratory Custody Procedures

A designated sample custodian at the laboratory will accept custody of the shipped samples from the carrier and enter preliminary information about the package into a package or sample receipt log, including the initials of the person delivering the package and the status of the custody seals on the coolers (i.e., broken versus unbroken). The custodian responsible for sample log-in will follow the laboratory's SOP for opening the package, checking the contents, and verifying that the information on the chain-of-custody agrees with samples received. The commercial laboratory will follow its internal chain-of-custody procedures as stated in the laboratory QA Manual.

3.4 Analytical Methods Requirements (Element B4)

3.4.1 Analytical Strategy

Analysis of samples collected during the TBA will be performed by several possible means. The EPA Region 10 laboratory (or alternative laboratory designated by the EPA) will perform all requested analyses with the exception of hazcatting, which will be performed on site by a START team member.

Table 3-2 lists the analyses to be applied to samples sent to the laboratory. These analyses were selected based on the probable hazardous substances used or potentially released to the environment, given the known or suspected site usage.

3.4.2 Analytical Methods

Table 3-3 summarizes the laboratory instrumentation and methods to be used for this TBA. Samples designated for off-site analytical laboratory analyses will be submitted to the EPA Region 10 laboratory, which is located in Manchester, Washington, or an alternative laboratory designated by the EPA. EPA and/or CLP laboratory analyses will take place within the standard three-week turnaround time period, with validation by the EPA QA office. Hard copy results from the EPA and/or CLP laboratories will be delivered to the EPA upon completion of each sample delivery group. Electronic results from the EPA and/or CLP laboratories will be delivered to the EPA upon project completion. Field analysis results will be provided the same day to the START PM.

All instruments and equipment used during field and fixed laboratory sample analyses will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations, as well as criteria set forth in the applicable analytical methodology references.

In the cases where laboratory results exceed QC acceptance criteria, re-extraction and/or reanalysis will occur as indicated in the applicable analytical method. The respective laboratory analysts will be responsible to ensure that appropriate sample analysis procedures are followed and take appropriate actions to ensure deficiency correction.

3.5 Quality Control Requirements (Element B5)

QC samples have been designated to determine the representativeness of the environmental samples, the precision of sample collection and handling procedures, the thoroughness of the field decontamination procedures, and the accuracy of the laboratory analysis. Table 3-3 identifies laboratory QC samples [i.e., matrix spike/matrix spike duplicate (MS/MSD) samples] that will be collected. Subsection 5.2 provides procedures used to reconcile analytical data with project data assessment parameters.

3.5.1 Field Quality Control

The types of field QC samples that will be collected are temperature blanks, rinsate blanks, and trip blanks.

3.5.1.1 Temperature Blanks

Temperature blanks are used by the laboratory to assess the temperature of the samples upon arrival at the laboratory. These blanks will be prepared in the field using a sample container and tap water. One blank will be placed in each cooler.

3.5.1.2 Rinsate Blanks

Rinsate blanks (equipment decontamination rinsates) are used to assess the adequacy of equipment decontamination practices employed for preventing cross-contamination between sampling locations and samples. Rinsate samples will be collected at a rate of at least one equipment blank for each group of 20 samples of a similar matrix type and concentration. The equipment decontamination rinsates are handled and analyzed in the same manner as all environmental samples.

3.5.1.3 Trip Blanks

Trip blank are used to assess the contamination attributable to shipping and field handling procedures (i.e., diffusion of volatile organics through the septum during shipment and storage). These blanks will be prepared in the field prior to the collection of VOC aliquots using a sample container and deionized water. One trip blank will be placed in each cooler used for VOC analysis.

3.5.2 Laboratory Quality Control

The analytical laboratory uses a series of QC samples specified in each standard analytical method and laboratory SOP to assess laboratory performance. Analyses of laboratory QC samples are performed for samples of similar matrix type and concentration and for each sample batch. The types of laboratory QC samples are MS/MSDs, laboratory duplicates, laboratory control standards, method blanks, and surrogates.

3.5.2.1 Matrix Spike/Matrix Spike Duplicates

MS/MSDs are used to assess sample matrix interference and analytical errors, as well as to measure the accuracy and precision of analysis. For MS or MSD samples, known concentrations of analytes are added to the environmental samples; the samples are then processed through the entire analytical procedure and the recovery of the analytes is calculated. Results are expressed as percent recovery of the known or spiked amount for MSs and the relative percent difference (RPD) for MS/MSDs.

Because MS/MSD samples measure the matrix interference of a specific matrix, samples designated for analysis as MS/MSD are project specific. The laboratory may not substitute a sample from another project to act as the QC sample for the analytical batch containing samples from this project. The MS/MSD samples will be analyzed for the same parameters as the associated field samples in the same QC analytical batch.

3.5.2.2 Laboratory Control Samples

Laboratory control samples (LCSs) are used to monitor the laboratory's day-to-day performance of routine analytical methods, independent of matrix effects. The LCSs are prepared by spiking reagent water with standard solutions prepared independently of those used in establishing instrument calibration. The LCSs are extracted and analyzed with each batch of samples. Results are compared on a per-batch basis and used to evaluate laboratory performance for accuracy. LCSs may also be used to identify any background contamination of the analytical system that may lead to the reporting of elevated concentrations or false-positive measurements.

3.5.2.3 Laboratory Duplicates

Laboratory duplicates are used to determine the precision of the analytical system. Laboratory duplicates are two portions of a single homogenous sample analyzed for the same parameter. Laboratory duplicates are typically prepared and analyzed when the analytical method does not require MS/MSD pairs. For example, samples undergoing metals or other inorganic analyses require an MS and a laboratory duplicated sample but not an MSD sample.

3.5.2.4 Method Blanks

Method blanks are used to check for laboratory contamination and instrument bias. Laboratory method blanks are analyzed at a minimum frequency of 5 percent, or one per analytical batch for all chemical parameter groups. Blank samples are analyzed for the same parameters as the associated field samples. Concentrations of analytes detected in the method blanks are not subtracted from the concentrations detected in the samples.

QC criteria require that minimum contamination be detected in the blank(s). If an analyte is detected, the following action is taken:

- If an analyte is found only in the method blank but not in the batch samples, no further corrective action is necessary. Steps will be taken to find/reduce/eliminate the source of this contamination in the method blank.
- If an analyte is found in the method blank at a concentration that exceeds the criterion and in some/all of the other batch samples, the method blank and any samples containing the same contaminant will be reanalyzed (within the holding times).
- If contamination remains at concentrations that exceed the criteria, the contaminated samples, a new method blank, and batch-specific QC samples will be reprepared and reanalyzed (within holding times).

3.5.2.5 Surrogate Spikes

Surrogate spikes are used to evaluate the accuracy of an analytical instrument. Surrogate compounds not expected to be found in environmental samples; however, they are chemically similar to several compounds analyzed by the methods and behave similarly in extracting solvents. Samples are spikes with compounds consistent with the requirements described in the analytical methods and in the laboratory SOP. Because samples characteristics affect the percent of recovery of the surrogate compounds, the percent recovery is a measure of the accuracy of the overall analytical method on each individual sample.

3.5.3 Standard Solutions

A critical element in the generation of quality data is the purity/quality and traceability of the standard solutions and reagents used in the analytical operation. To ensure the highest purity possible, all primary reference standards and standard solutions for use in the field and laboratory are obtained from the National Bureau of Standards, the EPA repository, or another reliable commercial source. The laboratory maintains a written record of the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information for all standards, standard solutions, and individual standard preparation logs.

Standard solutions are validated prior to use. Validation procedures range from a check for chromatographic purity to verification of the concentration of the standard solution using another standard solution prepared at a difference time of obtained from a different source. Stock and working standard solutions are checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change of concentration. Care is exercised in the proper storage and handling of standard solutions and all containers are labeled as to compound, concentration, solvent, expiration date, and preparation data (initials of preparer/date of preparation).

3.5.4 Laboratory Performance

The selected laboratory must ensure that all possible procedures for achieving minimum reporting limits are applied. These procedures include sample cleanup, increased aliquot size, and concentration of extracts. In addition, the laboratory must report (as estimated) all detected compounds whose concentrations are below the method reporting limit but above the method detection limit. If dilutions are necessary to bring individual target analytes within the calibration range, these analytes must be reported from the dilution; whereas, the remaining analytes must be reported from the nondiluted analytical run.

Laboratory requirements for compound identification are either described within the analytical methods used or this information is referenced to a general method that outlines procedures applicable to several methods. Laboratory SOPs must present procedures required to establish retention time windows (window width and location) for each target analyte for each chromatographic column employed in the analysis.

Laboratory requirements for compound confirmation are also presented within the analytical methods employed. For gas chromatography/mass spectrometry (GC/MS) methods, compound confirmation is obtained from the mass spectrum following specified procedures included within the methods, and no additional measures are needed. GC/MS or another analytical technique (if applicable), a dissimilar column (if available), or a second detector may be used for compound confirmation for GC and high-performance liquid chromatography (HPLC) methods. When using a secondary column, the analysis must meet the QC criteria for calibration, retention time, etc. If quantitative results are to be reported from the secondary column (i.e., when interferences are noted on the primary column), additional documentation must be furnished. This information must show that the same procedures for calibration and batch QC that are applied to the primary column are applied and successful on the secondary column.

Once confirmed, the agreement between the primary and secondary columns (or detectors) is compared to evaluate method performance and to decide the value to report (if applicable). The difference between the results is calculated as the RPD for comparability purposes only. These RPD values are generally not used to determine the presence/absence of the target analyte. Presence/absence is determined by the signal being present on both columns. When disparity in the results occurs, a review of the chromatograms is necessary to evaluate potential sources of error (overlapping peaks, matrix interference). When no evidence of interference is found, the larger of the values is reported to ensure that any decisions made on the basis of the data are conservative with regard to the environment.

3.5.5 Laboratory Corrective Action

The selected methods and QC requirements provided in this section are sufficient to meet the project DQOs. While a best effort will be made to achieve the project DQOs, there may be cases in which it is not possible to meet the specified goals. Any significant limitation in data quality caused by analyses that fail to meet the data quality indicators specified in this SQAP must be identified and brought to the attention of the E & E PM within 72 hours after discovering the limitation.

The laboratory must correct occurrences of noncompliance, such as poor analysis replication, poor spike recovery, instrument calibration problems, and blank contamination. Corrective action is taken at any time during the analytical process that is deemed necessary based on analytical judgment or when QC data indicate a need for action. Corrective actions include, but are not limited to, the following:

- Reanalysis;
- Recalculation;
- Instrument recalibration;
- Preparation of new standards/blanks;
- Re-extraction/digestion;
- Dilution;
- Application of another analysis method; and/or
- Additional training of analysts.

Incidents of noncompliance are documented so that corrective action may be taken to set the system back "in control." The following information constitutes a corrective action report, which must be approved and signed by the laboratory director and the laboratory QA manager:

- Where the noncompliance occurred;
- When the incident occurred and was corrected;
- Who discovered the noncompliance;
- Who verified the incident;
- Who corrected the problem; and
- Who verified the correction.

3.6 Instrument/Equipment Maintenance and Calibration

3.6.1 Instrument/Equipment Testing, Inspection, and Maintenance (Element B6)

Guidelines for preventative maintenance of instrument and equipment have been established by the manufacturers. Preventative maintenance will be implemented according to a schedule based on the type of stability of the instruments and equipment, required accuracy, intended use, and environmental factors. Preventative maintenance minimizes downtime and ensures the accuracy, precision, sensitivity, and traceability of data collected while using the instruments and equipment. Maintenance will be conducted by trained technicians, by using service manuals or through service agreements with qualified maintenance contractors. Instruments and equipment that are determined to be out of calibration or malfunctioning will be removed from operation until they have been recalibrated or repaired. In addition, backup for instruments/equipment and critical spare parts will be maintained to quickly correct malfunctions.

3.6.2 Instrument/Equipment Calibration and Frequency (Element B7)

The field equipment used during this project includes GPS equipment and a FID/PID. Testing, inspection, and maintenance of these instruments will be performed in accordance with the manufacturer's recommendations and/or the SOPs. Spare parts for the field equipment will be available from the manufacturer generally within 24 hours.

All field instruments and equipment used for analysis will be serviced and maintained only by qualified personnel. All instruments will be maintained by senior staff and/or electronics technicians. All repairs, adjustments, and calibrations will be documented in an appropriate logbook or data sheet that will be kept on file. The instrument maintenance logbooks will clearly document the date, the description of the problems, the corrective action taken, the result, and who performed the work.

3.6.3 Laboratory Instrument Maintenance and Calibration

The procedures for maintenance and calibration used by the analytical laboratories are included in their laboratory QA plans and analytical methods. All calibration standards must be traceable to the National Institute of Standards and Technology or other primary standards. Methods and intervals of calibration will be based on the type of equipment, stability characteristics, required accuracy, intended use, and environmental conditions.

Analytical balances are calibrated annually according to the manufacturer's instructions and have a calibration check before each use by laboratory personnel. Balance calibration is documented in appropriate hard-bound logbooks with prenumbered pages.

All refrigerators are monitored for proper temperature by measuring and recording internal temperatures on a daily basis. At a minimum, thermometers used for these measurements are calibrated annually, according to the manufacturer's instructions.

The project laboratory maintains an appropriate water supply system that is capable of furnishing ASTM Type II polished water to the various analytical areas.

3.6.4 Calibration and Maintenance Records

Calibration and maintenance schedules and records will be maintained for laboratory instruments and E & E-owned field equipment. Both equipment and equipment records will be located in a controlled-access facility when not in use. This is done to minimize equipment damage, theft, and tampering that may jeopardize either field or laboratory measurements and, ultimately, data quality.

3.7 Inspection/Acceptance of Supplies and Consumables (Element B8)

This information is covered by the SOPs, the START QAPP, and the START QMP (E & E 2005a). Standards contained in these documents will be used to ensure the validity of data generated by E & E for this project. Sample jars are pre- cleaned by the manufacturer; certification documenting this is enclosed with each box of jars. The START will include this documentation as part of the site file. Non-dedicated equipment is demonstrated to be uncontaminated by the use of rinsate blanks.

3.8 Data Acquisition Requirements/Nondirect Measurements (Element B9)

During this environmental data acquisition activity, data may be obtained from nondirect measurement sources, such as computer printouts and literature sources. The source of these data will be recorded, and the quality of the data will be assessed to determine if the data are consistent with project objectives and appropriate for supporting a specific decision. Usability or limitations of data, such as representativeness, bias, and precision, will be discussed, and any uncertainty will be assessed prior to the inclusion of data in the decision-making process.

3.9 Data Management (Element B10)

This document is meant to be combined with information presented in E & E's QAPP and QMP for Region 10 START. Copies of the START QAPP and QMP are available in E & E's Seattle office. Standards contained in these documents will be used to ensure the validity of data generated by E & E for this project. Data validation will be performed as listed in Section 4.1.2. Data tracking, storage, and retrieval are tracked through the TDD blue sheet, which records where the paper and electronic data are located. All paper data is stored in locked file cabinets; access to these files is restricted to key START personnel. Electronic data are archived by TDD number.

Table 3-1 Sample Collection Summary

Project Sampling Schedule[a]	Parameters/ Limits	Design Rationale	Sampling Design Assumptions	Sample Selection Procedures	Measurements Classification (Critical/ Noncritical)	Nonstandard Method Validation
Subsurface soil and sediment	TPH gasoline, TPH diesel, VOCs, SVOCs, and TAL Metals	Determine if contaminants are present	Contaminants were historically released to the soil and may have migrated via groundwater to adjacent sediments	Samples will be collected from potentially contaminated areas. [b]	Critical	NA
Groundwater	TPH gasoline, TPH diesel, VOCs, SVOCs, and TAL Metals	Determine if contaminants are present	Contaminants are migrating in groundwater onto the site or from the site	Samples will be collected from potentially contaminated areas. [b]	Critical	NA

Notes:
[a] All samples will be collected during the field event.
[b] As indicated from previous site visits and from on-site observations.

Key:
Critical = Required to achieve project objectives or limits on decision errors
Hazmat = Hazardous material
NA = Not Applicable
Noncritical = Not required to achieve project objectives
SVOCs = Semivolatile Organic Compounds
TAL = Target Analyte List
TPH = Total Petroleum Hydrocarbons
VOCs = Volatile Organic Compounds

Table 3-2 Sample Analysis Summary

Matrix	Quantity[a]	Analytical Parameters/ Method	Sample Preservation	Technical Holding Time[b]	Sample Container(s)
Soil and sediment	47 samples	TPH as Gasoline/NWTPH-Gx	Cool to 4ºC ± 2ºC	14 days from collection	Three 5-gram EnCore™ samplers plus one 40-mL VOA vial (for % moisture)
		TPH as Diesel/NWTPH-Dx	Cool to 4ºC ± 2ºC	14 days to extraction/ 40 days to analysis	One 8-oz. wide-mouth glass jar with Teflon lined lid.
		TAL metals/EPA 6000/7000 Series or CLP SOW ILM05.4	Cool to 4ºC ± 2ºC	180 days from collection	One 8-oz. wide-mouth glass jar with Teflon lined lid.
		VOCs/EPA 8260 B or EPA CLP SOW SOM01.2	Cool to 4ºC ± 2ºC	14 days to extraction/ 40 days to analysis	One 8-oz. wide-mouth glass jar with Teflon lined lid.
		SVOCs/EPA 8270C or EPA CLP SOW SOM01.2	Cool to 4ºC ± 2ºC	14 days to extraction/ 40 days to analysis	One 8-oz. wide-mouth glass jar with Teflon lined lid.
Water	7 samples	TPH as Gasoline/NWTPH-Gx	Cool to 4ºC ± 2ºC Hydrochloric acid to pH ≤ 2	14 days from collection	Three 40-milliliter glass VOA vials
		TPH as Diesel/NWTPH-Dx	Cool to 4ºC ± 2ºC Hydrochloric acid to pH ≤ 2	14 days to extraction/ 40 days to analysis	Two 32-ounce amber glass jars
		TAL metals/EPA 6000/7000 Series or CLP SOW ILM05.4	Cool to 4ºC ± 2ºC	7 days from collection/ 40 days to analysis	Two 32-ounce amber glass jars
		VOCs/EPA 8260 B or EPA CLP SOW SOM01.2	Cool to 4ºC ± 2ºC Hydrochloric acid to pH ≤ 2	14 days from collection	Three 40-milliliter glass VOA vials

Notes:
[a] The number of samples presented is an estimate; the actual number of samples to be collected will be determined in the field.
[b] Technical holding times have been established only for water matrices. Water technical holding times were applied to sediment, soil, and product samples when applicable; in some cases, recommended sediment/soil holding times are listed.
c. For VOCs utilize the low soil by SIM.

Key:
°C = Degrees Celsius; EPA = United States Environmental Protection Agency; oz = ounce; SVOCs = Semivolatile Organic Compounds; TAL = Target Analyte List;
TPH = Total Petroleum Hydrocarbons; VOA = volatile organic analytes; VOCs = Volatile Organic Compounds

Table 3-3 QA/QC Analytical Summary and Fixed Laboratory Analytical Methods

Laboratory	Matrix	Parameters/ Method	Method Description/ Detection Limits	Total Field Samples[a]/ Containers	QA/QC Sample Summary			Analyses/ Containers[d]	Precision and Accuracy[e]
					Organic MS/MSD[b]	Inorganic MS/D[b]	Rinsate & Trip Blanks[c]		
EPA Region 10 or Commercial Laboratory	Soil and sediment	TPH as Gasoline/NWTPH-Gx	GCS/FID / 5 mg/kg	47/188	3/24	NA	NA	50/212	± 35% 60% - 140%
		TPH as Diesel/NWTPH-Dx	GCS/FID / 25 mg/kg	47/47	3/0	NA	NA	50/47	± 35% 60% - 140%
		TAL metals/EPA 6000/7000 Series or CLP SOW ILM05.4	ICP & AA 1 mg/kg	47/47	NA	3/0	NA	50/47	± 35% 75% - 125%
		VOCs/EPA 8260 B or EPA CLP SOW SOM01.2	GC/MS/ 0.1 mg/kg	47/188	3/24	NA	NA	50/212	± 35% 60% - 140%
		SVOCs/EPA 8270C or EPA CLP SOW SOM01.2	GC/MS/ 0.1 mg/kg	47/47	3/0	NA	NA	50/47	± 35% 60% - 140%
	Water	TPH as Gasoline/NWTPH-Gx	GCS/FID / 0.25 mg/L	7/21	1/6	NA	2/6	10/33	± 20% 60% - 140%
		TPH as Diesel/NWTPH-Dx	GCS/FID / 0.25 mg/L	7/14	1/4	NA	1/2	9/20	± 20% 60% - 140%
		TAL metals/EPA 6000/7000 Series or CLP SOW ILM05.4	ICP-MS & AA/ 0.2 µg/L	7/7	NA	1/1	1/1	9/9	± 20% 75% - 125%
		SVOCs/EPA 8270C or EPA CLP SOW SOM01.2	GC/MS/ 5 µg/L	7/14	1/4	NA	1/2	9/20	± 20% 60% - 140%
		VOCs/EPA 8260 B or EPA CLP SOW SOM01.2	GC/MS/ 0.01 µg/L	7/21	1/6	NA	2/6	10/33	± 20% 60% - 140%

Notes:

[a] Total number of field samples is estimated.

[b] No extra volume is required for soil/sediment or product samples; for water samples, triple volume is required for organic analyses, and double volume is required for inorganic analyses. Sample numbers are based on MS/MSD per 20 samples per matrix.

[c] Rinsate blanks are not applicable for dedicated sampling equipment. The total number of trip blanks could vary depending on the total number of sample shipments. This number is based on the estimated number of shipping containers. Note that trip blanks consist of water aliquots for both soil and water field samples.

[d] Total analyses and containers include both field and QA/QC aliquots to be submitted for fixed laboratory analysis. Note that trip blanks and rinsate blanks consist of water aliquots for both soil and water field samples.

[e] Advisory limits are shown. Laboratory- and method-specific QC limits will be used.

f. For VOCs utilize the low soil by SIM.

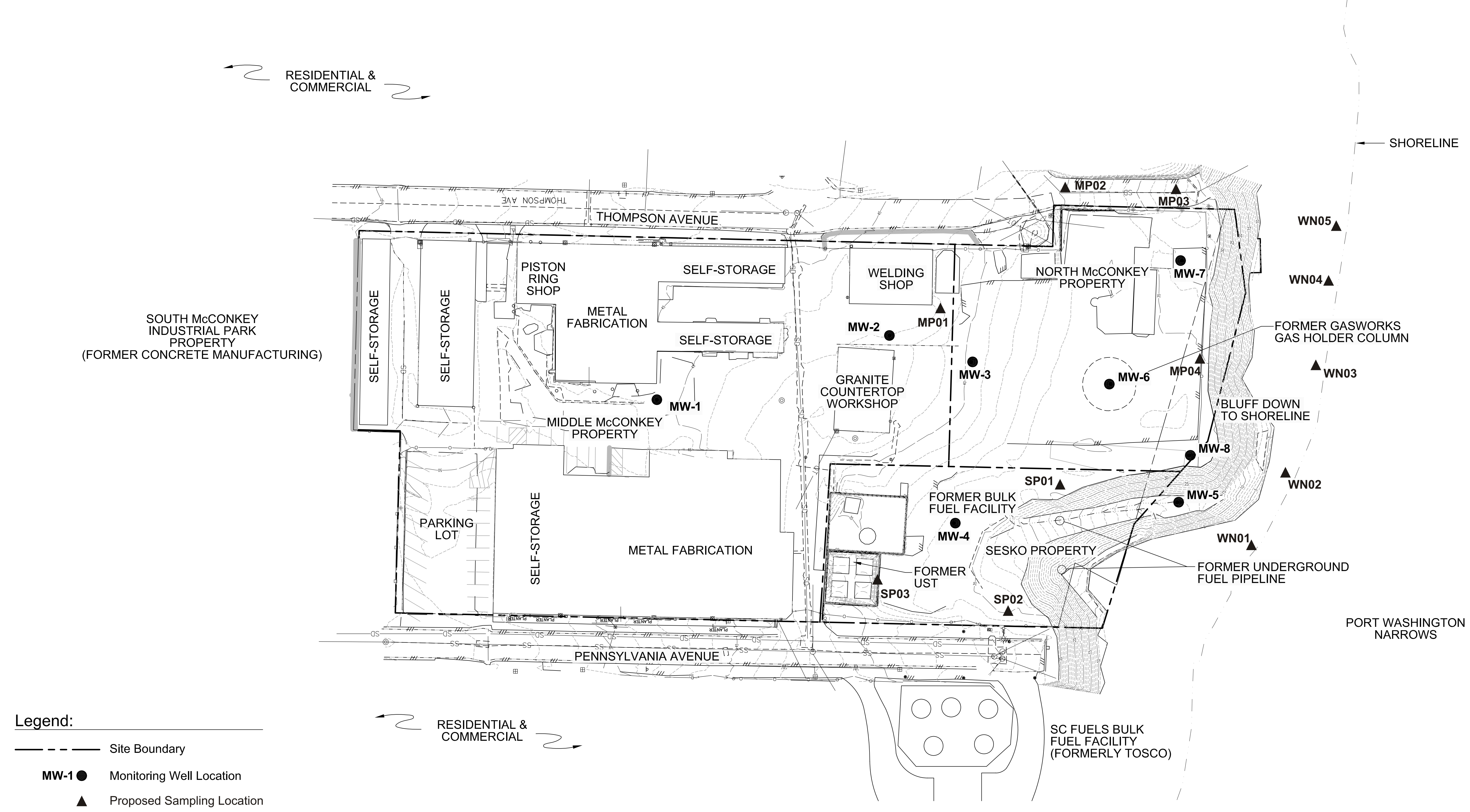
Key:

CVAAS = Cold Vapor Atomic Absorption Spectroscopy; ECD = Electron capture detection; EPA = United States Environmental Protection Agency; FID = Flame ionization detector; GC = Gas chromatography; GCS = gas chromatographic separation; HRGC = High Resolution Gas Spectrometry; HRMS = High Resolution Mass Spectrometry; ICP = Inductively coupled argon plasma; mg/kg = milligrams per kilogram; mg/L = milligrams per liter; MS = Mass spectrometric detection; MS/D = Matrix spike/duplicate; MS/MSD = Matrix spike/matrix spike duplicate; NA = not applicable; ng/kg = nanograms per kilogram; QA = quality assurance; QC = quality control; SVOCs = semi-volatile organic compounds ; TAL = Target Analyte List; TPH = total petroleum hydrocarbons; µg/L = micrograms per liter; VOCs = volatile organic compounds.

Table 3-4 Sample Coding

Digits	Description	Code	Example
1,2	Source Area	MP	McConkey Properties
		SP	Sesko Properties
		WN	Washington Narrows
3,4	Consecutive Number	01	First Sample of Source Type
5,6	Matrix Code	GW	Groundwater
		RS	Rinsate
		SB	Subsurface Soil
		SD	Sediment
		TB	Trip Blank
7,8	Consecutive Number	01	Subsurface soil depth interval

Base Map Reference: GeoEngineers 2007.



ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

0 70 140
Approximate Scale in Feet

BREMERTON GASWORKS TBA
Bremerton, Washington

Figure 3-1
PROPOSED SAMPLING LOCATIONS

Date:	Drawn by:	
2/15/08	AES	10:START-3\07010008\fig 3-1

4 Assessment/Oversight

4.1 Assessment and Response Actions (Elements C1 and C2)

The EPA QA manager or designee may conduct an audit of the field activities for this project. The auditor will have the authority to issue a stop work order upon finding a significant condition that would adversely affect the quality and usability of the data. The EPA TM will have the responsibility for initiating and implementing response actions associated with findings identified during the site audit. The actions taken may also involve the EPA Project Officer, Contracting Officer, and/or QA Officer. Once the response actions have been implemented, the EPA QA manager or designee may perform a follow-up audit to verify and document that the response actions were implemented effectively. In-house audits performed by the START may be conducted in accordance with the E & E START QMP. No audits are planned for the Bremerton Gasworks TBA.

4.1.1 Independent Technical Reviews

Independent technical reviews will be performed on all deliverable documents, including this SQAP and the draft and final Bremerton Gasworks TBA reports. These reviews will be conducted by experienced and qualified personnel to ensure the quality and integrity of tasks and products by allowing the work and/or deliverables to undergo objective, critical scrutiny.

4.1.2 Data Quality Assessments

Data quality assessments will be prepared to document the overall quality of data collected in terms of the established quality criteria/indicators. The data assessment parameters calculated from the results of the field measurements and laboratory analyses will be reviewed to ensure that all data used in subsequent evaluations are scientifically valid, of known and documented quality, and, where appropriate, legally defensible. In addition, the performance of the overall measurement system will be evaluated in terms of the completeness of the project plans, effectiveness of field measurement and data collection procedures, and relevance of laboratory analytical methods used to generate data as planned. Finally, the goal of the data quality assessment will be to present the findings in terms of data usability.

The major components of a data quality assessment, which are provided in the following list, show the logical progression of the assessment leading to a determination of data usability:

- Summary of the problems, data generation trends, general conditions of the data, and reasons for data qualification as presented in the laboratory data narrative.
- Evaluation of QC samples, such as trip blanks, equipment rinsates, and LCSs to assess the quality of the field activities and laboratory procedures.
- Assessment of the quality of data measured and generated in terms of accuracy, precision, and completeness.
- Summary of data usability. Sample results for each analytical method are qualified as acceptable, rejected, estimated, biased high, or biased low.

4.2 Nonconformance and Corrective Action

The project plans, supplementary procedures, SOPs, and training establish the baseline for assessing the quality system. Management and technical staff will follow these plans and procedures during the course of any project activity. However, on occasion, nonconformances do occur. Each nonconformance will be documented by project personnel observing the nonconformance. Examples of nonconforming work include the following:

- Errors made in following work instruction or improper work instruction;
- Unforeseen or unplanned circumstances that result in services that do not meet quality/contractual/technical requirements;
- Unapproved or unwarranted deviations from established procedures;
- Nonvalidated or nonverified computer programs;
- Missing or deficient sample chain-of-custody documentation; and
- Data that fall outside of established DQO criteria.

Results of QA reviews and audits typically identify the requirement for a corrective action. The QAO is responsible for reviewing all audit and nonconformance reports to determine areas of poor quality or failure to adhere to established procedures. Nonconformances will be formally reported by the QAO for the PM. The PM is responsible for evaluating all reported nonconformances, determining the root causes, conferring with the QAO on the steps to be taken for correction, and executing the corrective action as developed and scheduled. Corrective action measures will be selected to prevent or reduce the likelihood of future occurrences and to address the root causes to the extent identifiable. Selected measures will be appropriate to the seriousness of the nonconformance and will be realistic in terms of the resources required for implementation.

In summary, corrective action involves the following steps:

- Discovery of nonconformances;
- Identification of the responsible party;
- Determination of root causes;
- Development of a plan and schedule for corrective/preventative action;
- Review of the corrective action taken; and
- Confirmation that the desired results were produced.

Upon completion of the corrective action, the QAO will evaluate the adequacy and completeness of the action taken. If the action is found to be inadequate, the QAO and PM will confer to resolve the problem and determine any further actions. Implementation of any further action will be scheduled by the PM. The QAO will issue a suspend or stop work notice with the concurrence of the PM and the EPA in cases where significant problems continue to occur or a critical situation requires work to prevent further discrepancies, loss of data, or other problems. When the corrective action is found to be adequate, the QAO will notify the PM of the completion of the audit.

The QAO maintains a log of nonconformances in order to tack their disposition until correction and for trend analysis if necessary. All documentation associated with a nonconformance is entered into the project files and QA administrative files.

5 Data Validation and Usability

5.1 Data Review, Validation, and Verification (Elements D1 and D2)

The data validation review of data packages will include an evaluation of the information provided on the analytical data sheets and required support documentation for all sample analyses; the supporting sample collection documentation, including chain of custody; and field instrument calibration, results, and/or performance check documentation (if required by the method). The QA review will also examine adherence to the procedures as described in the cited SOPs and the requested analytical methods.

5.2 Reconciliation with Data Quality Objectives (Element D3)

Once the data results are compiled, the EPA TM and/or the EPA QA Officer will review the sample results to determine if they fall within the acceptance limits as defined in this SQAP. Completeness will also be evaluated to determine if the completeness goal for this project has been met. If data quality indicators do not meet the project's requirements as outlined in this SQAP, the data may be discarded and resampling and reanalysis may occur. The TM will attempt to determine the cause of the failure (if possible) and make the decision to discard the data and resample. If the failure is tied to the analysis, calibration and maintenance techniques will be reassessed as identified by the appropriate laboratory personnel. If the failure is associated with the sample collection and resampling is required, the collection techniques will be reevaluated as identified by the START PM.

5.2.1 Precision

Precision measures the reproducibility of measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Analytical precision is the measurement of the variability associated with duplicate (two) or replicate (more than two) analyses. The LCS determines the precision of the analytical method. If the recoveries of the analytes in the LCS are within established control limits, then precision is within limits. In this case, the comparison is not between a sample and a duplicate sample analyzed in the same batch. Rather, the comparison is between the sample and samples analyzed in previous batches.

Total precision is the measurement of the variability associated with the entire sampling and analysis process. It is determined by analysis of duplicate or replicate field samples and measures variability introduced by both the laboratory and field operations. Field duplicate samples and matrix duplicate spiked samples shall be analyzed to assess field and analytical precision, and the precision measurement is determined using the RPD between the duplicate sample results.

The following formula is used to calculate precision:

$$RPD = (100) \times \frac{(S1 - S2)}{(S1 + S2)/2}$$

where:

S1 = original sample value
S2 = duplicate sample value

5.2.2 Accuracy

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error. It reflects the total error associated with a measurement. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike and standard. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into an LCS to a control limit. For volatile and semi-volatile organic compounds, system monitoring compound recoveries are also used to assess accuracy and method performance for each sample analyzed. Analysis of performance evaluation samples may also be used to provide additional information for assessing the accuracy of the analytical data being produced.

The percent of accuracy is calculated from the following equation:

$$\frac{\text{Conc. of Spike/surrogate compound detected in MS sample} - \text{Conc. detected in the sample} \times 100}{\text{Amount of spike/surrogate compound added to the MS sample}}$$

5.2.3 Completeness

Completeness is calculated for the aggregation of data for each analyte measured for any particular sampling event or other defined set of samples. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not rejected through data validation. The requirement for completeness is 95% for aqueous samples and 90% for soil and sediment samples.

The percent of completeness is calculated from the following equation:

$$\frac{\text{number of valid results} \times 100}{\text{number of possible results}}$$

For any instances of samples that could not be analyzed for any reason (holding time violations in which resampling and analysis were not possible, samples spilled or broken, etc.), the numerator of this calculation becomes the number of valid results minus the number of possible results not reported.

For this investigation, all samples are considered critical. Therefore standard collection (as defined in the sampling SOPs of Appendix A) and measurement methods will be used to achieve the completeness goal.

5.2.4 Representativeness

Representativeness is a measure of the degree to which data accurately and precisely represents a population, including a sampling point, a process condition, or an environmental condition. Representativeness is the qualitative term that should be evaluated to determine that measurements are made, and physical samples collected, at locations and in a manner resulting in characterizing a matrix or media. Subsequently, representativeness is used to ensure that a sampled population represents the target population and an aliquot represents a sampling unit. This SQAP will be implemented to establish representativeness for this project. Further, all sampling procedures detailed in the SQAP will be followed to ensure that the data will be representative of the media sampled. The SQAP describes the sample location, sample collection and handling techniques that will be used to avoid contamination or compromise sample integrity, and proper chain-of-custody of samples. Additionally, the sampling design presented in the SQAP will ensure that there are a sufficient number of samples and level of confidence that analysis of these samples will detect the chemicals of concern, if present.

5.2.5 Comparability

Comparability is the qualitative term that expresses the measure of confidence that two data sets or batches can contribute to a common analysis and evaluation. Comparability with respect to laboratory analyses pertains to method type comparison, holding times, stability issues, and aspects of overall analytical quantitation. The following items are evaluated when assessing data comparability:

- Determining if two data sets or batches contain the same set of parameters.
- Determining if the units used for each data set are convertible to a common metric scale.
- Determining if similar analytical procedures and quality assurance were used to collect data for both data sets.
- Determining if the analytical instruments used for both data sets have approximately similar detection levels.
- Determining if samples within data sets were selected and collected in a similar manner.

To ensure comparability of data collected during this investigation to other data that may have been or may be collected for each property, standard collection and measurement techniques will be used.

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A Standard Operating Procedures

Title:	**FIELD ACTIVITY LOGBOOKS**
Category:	DOC 2.1
Revised:	April 1998

STANDARD OPERATING PROCEDURE

FIELD ACTIVITY LOGBOOKS

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1. Summary

This Standard Operating Procedure (SOP) establishes requirements for the entry of information into logbooks to ensure that E & E field activities are properly documented. The project manager (PM) and the field team leader (FTL) are responsible for ensuring that logbook entries provide sufficient information for the completion of an accurate and detailed description of field operations and meets the requirements of the contract or technical direction document (TDD).

This SOP describes logbook entry requirements for all types of projects, specifies the format that should be used, and provides examples. Some flexibility exists when implementing the SOP because different types of projects require different data collection efforts. This SOP does not address site safety logbook requirements or geotechnical logbook entries.

2. Purpose

Complete and accurate logbook entries are important for several reasons: to ensure that data collection associated with field activities is sufficient to support the successful completion of the project; to provide sufficient information so that someone not associated with the project can independently reconstruct the field activities at a later date; to maintain quality control (QC) throughout the project; to document changes to or deviations from the work plan; to fulfill administrative needs of the project; and to support potential legal proceedings associated with a specific project.

2.1 Adequate Field Information/Quality Control

QC procedures for data collection begin with the complete and systematic documentation of all persons, duties, observations, activities, and decisions that take place during field activities. It is especially important to fully document any deviations from the contract, project scope, work plans, sampling plans, site safety plans, quality assurance (QA) procedures, personnel, and responsibilities, as well as the reasons for the deviations.

Prior to entering the field, the project manager must indicate to the field team what pertinent information must be collected during field activity in order to meet the desired objectives of the data collection effort. The PM is responsible for reviewing the adequacy of the project logbooks both during and following completion of field activities, and is also responsible for meeting with the field team members to discuss any findings and to direct activities to correct any deficiencies, as appropriate. The PM also has the responsibility of ensuring that the logbooks become part of the project or TDD file.

2.2 Work Plan Changes/Deviation

The logbook is the document that describes implementation of the work plan and other appropriate contract documents and provides the basis for the project reports. It must include detailed descriptions of any and all deviation from the work plan and the circumstances that necessitate such changes. These changes will be reviewed for compliance with data quality objectives and include:

- Changes in procedures agreed to in the project planning stages;

- Any conditions that prevent the completion of the field effort, or that result in additional fieldwork must be noted (i.e., weather delays, government actions, physical obstructions, personnel/ equipment problems, etc.). Persons from whom permission was obtained to make such changes must be clearly documented.

- Any modifications requested by the client or client's representative that are contradictory to the contract or outside of the existing scope of work must be documented in detail because the cost of the project could be affected by such modifications.

2.3 Evidentiary Documentation

Field activity documentation can become evidence in civil and/or criminal judicial proceedings, as well as in administrative hearings. Field logbooks serve this purpose. Accordingly, such documentation is subject to judicial or administrative review. More importantly, it is subject to the review of an opposing counsel who will attempt to discredit its evidentiary value.

The National Enforcement Investigation Center (NEIC) and the United States Environmental Protection Agency (EPA) have prepared documents outlining their documentation needs for legal proceedings. These guidelines indicate the importance of accurate and clear documentation of information obtained during the inspections, investigations, and evaluations of uncontrolled hazardous waste sites. Consequently, attention to detail must be applied by E & E personnel to all field documentation efforts for all E & E projects. Project personnel must document where, when, how, and from whom any vital project information was obtained. This information is necessary to establish a proper foundation for admissible evidence.

3. Guidelines

Logbooks should contain a summary of any meeting or discussion held with a client or with any federal, state, or other regulatory agency that was on site during the field activities. The logbook should also describe any other personnel that appear on site, such as representatives of a potential responsible party (PRP).

The logbook can be used to support cost recovery activities. Data concerning site conditions must be recorded before the response activity or the passage of time eliminates or alters those conditions. Logbooks are also used to identify, locate, label, and track samples and their final disposition. In addition, data recorded in the logbook will assist in the interpretation of the analytical results.

Logbooks are subject to internal and external audits. Therefore, the recorded information should be consistent with and capable of substantiating other site documentation such as time cards, expense reports, chain-of-custody forms, shipping papers, and invoices from suppliers and subcontractors, etc. Logbooks also act as an important means of reconstructing events should other field documents such as data collection forms become lost or destroyed. Therefore, all mission-essential information should be duplicated in the logbook.

3.1 General Instructions

The following general guidelines must be used for all logbooks:

- At a minimum, one separate field activity logbook must be maintained for each project or TDD.
- All logbooks must be bound and contain consecutively numbered pages.
- No pages may be removed for any reason, even if they are partially mutilated or illegible.
- All field activities must be recorded in the site logbook (e.g., meetings, sampling, surveys, etc.).
- All information must be **printed legibly** in the logbook using water-proof ink, preferably black. If weather conditions do not permit this (i.e., if it is too cold or too wet to write with ink), another medium, such as pencil, may be used. The reason that waterproof ink was not used should be specifically noted in the logbook.
- The language used in the logbook should be objective, factual, and free of personal feelings or terminology that might prove inappropriate.
- Entries should be made in chronological order. Contemporaneous entries are always preferred because recollections fade or change over time. Observations that cannot be recorded during field activities should be recorded as soon after as possible. If logbook entries are not made during field activities, the time of the activity/ observation and the time that it is recorded should be noted.
- The first entry for each day will be made on a new, previously blank page.
- Each page should be dated and each entry should include the time that the activity occurred based on the 24-hour clock (e.g., 0900 for 9 a.m., 2100 for 9 p.m.).
- At the completion of the field activity, the logbook must be returned to the permanent project or TDD file.

3.2 Format

The information presented below is not meant to be all-inclusive. Each project manager is responsible for determining the specific information requirements associated with a field activity logbook. If someone other than the Project Manager is keeping the logbook, the Project Manager is responsible to convey to that individual, prior to the start of fieldwork, specific instructions on what type of information is required to be entered into the logbook. Information requirements will vary according to the nature and scope of the project. (Refer to Appendix A for an example of a completed logbook.)

Title Page

The logbook title page should contain the following items:

- Site name,
- Location,
- TDD No. or Job No.,
- PAN (an EPA site/task identification number), if applicable,
- SSID No. (Site ID number-assigned under CERCLA), if applicable,
- Start/Finish date, and
- Book ___ of ___.

First Page

The following items should appear on the first page of the logbook prior to daily field activity entries:

- TDD No. or Job No.,
- Date,
- Summary of proposed work (Reference work plan and contract documents, as appropriate),
- Weather conditions,
- Team members and duties, and
- Time work began and time of arrival (24-hour clock).

Successive Pages

In addition to specific activity entries and observations, the following items should appear on every logbook page:

- Date,
- TDD or Job No., and
- Signature (bottom of each page). If more than one person makes entries into the logbook, each person should sign next to his or her entry.

Last Page

In addition to specific activity entries and observations and the items that should appear on each successive page, the last page of the logbook should contain a brief paragraph that summarizes the work that was completed in the field. This summary can become especially important later on if more or less work was accomplished during the duration of the field activity.

3.3 Corrections

If corrections are necessary, they must be made by drawing a single line through the original entry in such a manner that it can still be read. *Do not erase or render an incorrect notation illegible*. The corrected entry should be written beside the incorrect entry, and the correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

4. Documentation

Although the requirements and content of the field logbook will vary according to the site and the tasks to be performed, the following information should be included in every logbook:

4.1 Prior to Fieldwork

Summary of Proposed Work

The first paragraph of **each** daily entry should summarize the work to be performed on that day. For example:

> "Collect soil and groundwater samples from previously installed wells and ship samples to Analytical Services Center (ASC). Discuss removal with site owner."

The first paragraph becomes especially important later when discussing work plan deviations or explaining why more or less work was accomplished for that day.

Personnel

Each person to be involved in activities for the day, his/her respective role (sampler, health and safety, etc.), and the agency he/she represents should be noted in the logbook.

On-Site Weather Conditions

Weather conditions may have an impact on the work to be performed or the amount of time required to perform the proposed work; therefore, all weather on-site weather conditions should be noted, including temperatures, wind speed and direction, precipitation, etc., and updated as necessary. Similarly, any events that are impacted by weather conditions should be noted in the logbook.

Site Safety Meeting

Although minutes should be recorded for all site safety meetings under separate cover, the logbook should briefly summarize the site safety meeting and any specific site conditions and resultant site safety concerns.

4.2 Site Sketch

A site sketch should be prepared on the first day of field activities to indicate prominent site and environmental features. The sketch should be made either to scale or by noting the approximate distances between site feature. Area-specific sketches should be prepared as work is undertaken in such areas, and updated sketches should be drawn as work progresses.

Site Features

Examples of features to be noted on the site sketch include the following:

- Structures such as buildings or building debris;
- Drainage ditches or pathways, swales, and intermittent streams (include direction of overland runoff flow and direction of stream flow);
- Access roads, site boundaries, and utility locations;
- Decontamination and staging areas;
- Adjacent property data: the type of property that borders the site, information pertaining to ownership, and available addressees; and
- North arrow.

Changes in Site Conditions

Any deviation from previous site sketches or drawings presented in the work plan, and any changes that have occurred since the last site visit must be noted. Differences to be noted include the following:

- Demolished buildings;
- Changes to access routes;
- Damage to wells or equipment, or changes to the amount of such equipment believed to be on site,
- Changes resulting from vandalism;
- Destruction of reference points;
- Changes resulting from environmental events or natural disasters; and
- Locations of excavations, waste piles, investigation-derived waste (IDW), drum staging areas, etc.

In short, *any* site condition that varies from the conditions described in the work plan should be noted.

4.3 Monitoring Equipment and Activities

Any monitoring equipment used during field activities should be documented in the log-book. Information to be noted includes:

- The type of equipment with model and serial numbers. (HNu, OVA, etc.);
- The frequency at which monitoring is performed;
- Calibration results and the frequency at which the equipment is cali-brated or tested;
- Background readings;
- Any elevated or unusual readings; and
- Any equipment malfunctions.

It is particularly important to note elevated or unusual equipment readings because they could have an impact on personal protection levels or the activities to be performed on site. If a change in the proposed work or protection levels occurs, it should be clearly noted in the logbook.

4.4 Sample Collection Activities

Because it represents the first step in an accurate chain-of-custody procedure, field sampling documentation must be complete. The following items should be documented in the logbook:

Sample Collection Procedures

The following items pertaining to sample collection procedures should be included in the logbook:

- Any pre-sampling activities (i.e., well purging and the number of volumes purged before sample collection);
- Results of the pre-sampling activities (i.e., pH/conductivity/ temperature readings for well water, results of hazard categorization testing, etc.);
- Any environmental conditions that make sample collection difficult or impossible (i.e., dry or flooded drainage paths, inclement weather conditions, etc.); and
- Any deviation from the work plan (i.e., additional samples and the reason for their collection, alternate sample locations, etc.).

Sample Information

The following information regarding sample data should be recorded in the logbook:

- Sample number and station location including relationship to permanent reference point(s);
- Name(s) of sampler(s);
- Sample description and any field screening results;
- Sample matrix and number of aliquots if a composite sample;
- Preservatives used, recipient laboratory, and requested analyses;
- QA/QC samples; and
- Shipping paper (airbill) numbers, chain-of-custody form numbers, and jar lot numbers.

Investigation-Derived Waste/Sample Shipment

Details pertaining to sampling equipment, decontamination, and IDW should be clearly delineated in the work plan. However, the following information should be included in the log-book:

- The type of IDW generated an the number of containers generated (each drum should be numbered and its contents noted);
- All information relevant to the characterization of the IDW;
- Any directions received from the client/workplan/contract relative to the management of the IDW;
- The disposition of IDW (left on site or removed from site);
- The number of sample containers shipped to the ASC or laboratory and the courier used (i.e., Federal Express, Airborne Express, etc.);
- Airbill or shipment tracking numbers; and
- The type of paperwork that accompanied the waste/sample shipment (e.g., manifests, etc.).

4.5 Photodocumentation

Photographs should be taken during all relevant field activities to confirm the presence or absence of contaminants encountered during fieldwork. Specific items to be documented in-clude:

- Sample locations and collection activities;
- Site areas that have been disturbed or impacted, and any evidence of such impacts (i.e., stressed vegetation, seepage, discolored water, or debris);
- Hazardous materials requiring disposal, including materials that may not appear in the work plan;
- Any evidence that attests to the presence or absence of contamination; and
- Any features that do not appear in the work plan or differ from those described in the work plan.

Documentation of any photographs taken during the course of the project must be provided in the logbook with a detailed description of what is shown in the photograph and the reason for taking it. This documentation should include:

- Make, model, and serial numbers of the camera and lens,
- Film type and number of exposures,
- Roll and frame number of the photograph;
- Direction or view angle of the photograph, and
- Name of the photographer.

4.6 Data Collection Forms

Certain phases of fieldwork may require the use of project-specific data collection forms, such as task data sheets or hazard categorization data sheets. Due to the specific nature of these forms, the information that should be included in the logbook cannot be fully discussed in this SOP. However, the following data should be included in the logbook:

- Results of any field tests or hazard categorization tests (i.e., ignitability, corrosivity, reactivity, etc.);
- The source from which any field sample was collected and its condition (i.e., drum, tank, lagoon, etc.).
- Other conclusions as a result of the data collected on data collection forms.

In many cases, rubber stamps that contain routine data collection forms can be manufactured ahead of time. These forms can be stamped into the logbook on an as-needed basis.

Appendix A

Sample Logbook

RI 6130

WEDNESDAY JANUARY 26, 1994

PROPOSED WORK FOR DAY: COLLECT GROUNDWATER SAMPLES FROM WELLS AND PIEZOMETERS AT SITE 1 AND SITE 3. SHIP SAMPLES TO THE ASC. CONTAINERIZE PURGE WATER. MEET WITH FRED CANSLER AND DISCUSS REMOVAL OF CANOPIES AT SITES 1 AND 3 AND FILLING OF EXCAVATIONS.

WEATHER ON SITE: CLOUDY AND WARM WITH A HIGH TEMPERATURE OF 50° F. RAIN SHOWERS WITH WINDS FROM THE SW AT 5-15 MPH.

E&E PERSONNEL ON SITE: G. JONES, J. MAYS, S. MC CUNE

LOG

1330 ARRIVED ON SITE. THE GROUNDWATER SAMPLING CREW WAS PREPARING TO PURGE THE WELLS AND PIEZOMETERS IN THE FIELD ACROSS THE ROAD FROM SITE 1. PURGING OF WELLS BEING COMPLETED WITH HAND BAILERS SINCE PUMP IS INOPERATIVE.

1340 ARRIVED AT SITE 3. MW3-1 AND MW3-3 UNLOCKED AND OPEN; SECURED BOTH WELLS.

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RI 6130 1/26/94

1330 FRED CANSLER ARRIVED ON SITE. DISCUSSED REMOVAL OF CANOPIES AND CLOSURE OF EXCAVATIONS AT SITES 1 AND 3. FRED CANSLER STATED THAT HE HAS A SOURCE FOR THE ROCK AND FOR THE TOP SOIL FOR THE EXCAVATIONS.

1405 ARRIVED AT THE SITE WHERE FRED CANSLER PROPOSES TO REMOVE THE FILL FOR THE EXCAVATIONS. A HILL ON THE WEST SIDE OF THE WARDEN NICKLE IS IN THE PROCESS OF BEING REMOVED. THE ROCK CONSISTS OF WEATHERED SHALE SIMILAR TO THE ROCK REMOVED FROM THE EXCAVATIONS. FRED CANSLER PROPOSES TO USE THE ROCK TO FILL THE EXCAVATIONS TO WITHIN ONE FOOT OF GRADE.

1415 ARRIVED AT THE SITE WHERE FRED CANSLER PROPOSES TO REMOVE TOP SOIL FOR THE EXCAVATIONS. TOP SOIL REMOVED FROM THE YELLOW FREIGHT LOT IS IN PILES ON THE NORTH SIDE OF THE LOT.

1430 RETURNED TO SITE 3. FRED CANSLER WILL ARRANGE TO REMOVE THE CANOPY OVER THE EXCAVATION AT SITE 3 ON THURSDAY MORNING AND WILL ARRANGE TO BRING THE ROCK IN ON THURSDAY AFTERNOON. TWO TRUCKS WILL BE USED TO HAUL THE FILL. THE SUPPORTS HOLDING THE CANOPY

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1/26/94 RI6130

1430 (CONT) WILL BE CUT AND THE CANOPY DRAGGED AWAY FROM THE EXCAVATION.

1445 CONTACTED JOY INMAN FROM ENVIRONICS. TANKERS WILL BE ON SITE ON THURSDAY TO PUMP OUT THE EXCAVATION AT SITE 3 AND ON FRIDAY TO REMOVE WATER AT SITE 1. A FRAC TANK WILL BE DELIVERED TO SITE 1 ON THURSDAY.

1515 SAMPLING CREW COMPLETED PACKING SAMPLES COLLECTED AT SITE 1. ALL WELLS AND PIEZOMETERS AT SITE 1 HAVE BEEN SAMPLED.

1530 SAMPLING CREW COMPLETED PACKING SAMPLES AND SECURING DRUMS OF PURGE WATER.

1535 SAMPLING CREW DEPARTED SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.

1600 CONTACTED TIM GRADY FROM E+E. DISCUSSED CONVERSATION WITH FRED CANSLER AND STATUS OF WELL/PIEZOMETER SAMPLING.

1615 SECURED FOR DAY.

WORK COMPLETED: COLLECTED GROUNDWATER SAMPLES FROM SITE 1 WELLS AND PIEZOMETERS. DISCUSSED REMOVAL OF CANOPIES AND FILLING OF EXCAVATIONS WITH FRED CANSLER. SHIPPED SAMPLES TO ASC

[signature] 1/26/94

40

RI6130

THURSDAY JANUARY 27, 1994

PROPOSED WORK FOR DAY: COMPLETE COLLECTION OF GROUNDWATER SAMPLES AT SITE 3 AND SHIP THE SAMPLES TO THE ASC. REMOVE THE CANOPIES COVERING THE EXCAVATIONS AT SITES 1 AND 3. PUMP THE WATER OUT OF THE EXCAVATIONS AT SITES 1 AND 3 AND SHIP THE WATER OFF SITE TO OSCO. BACKFILL THE EXCAVATION AT SITE 3. REMOVE THE DRUMS FROM THE ROLL OFF BOX AND TRANSFER THE DRUMS TO THE WAREHOUSE.

WEATHER ON SITE: CLOUDY AND COOL WITH A HIGH TEMPERATURE OF 45°F. WINDS VARIABLE 10-20 MPH.

E+E PERSONNEL ON SITE: G. JONES, J. MAYS, S. McCUNE

LOG

0700 SCOTT McCUNE ARRIVED AT SITE 3.

0710 ENVIRONICS PERSONNEL ARRIVED AT SITE 3.

0715 HELD SITE SAFETY MEETING. DISCUSSED PHYSICAL AND CHEMICAL HAZARDS ASSOCIATED WITH SITE AND PROPOSED WORK FOR THE DAY.

0725 E+E SAMPLING TEAM ARRIVED ON SITE

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0730 E+E SAMPLING CREW COMMENCED COLLECTING SAMPLES AND PURGING MW 3-1 AND MW 3-2.

0800 FRED CANSLER ARRIVED ON SITE WITH PERSONNEL TO REMOVE THE CANOPY OVER THE EXCAVATION AT SITE 3. THE SUPPORTS WERE CUT AND THE CANOPY WAS DRAGGED AWAY FROM THE EXCAVATION WITH TWO TRACTORS.

0845 THE CANOPY REMOVAL AT SITE 3 COMPLETED AND THE CREW DEPARTED FOR SITE 1.

0850 COMMENCED PUMPING WATER FROM THE EXCAVATION INTO BRYSON TRAILER # 618CS.

0915 THE E+E SAMPLING TEAM COMPLETED COLLECTING THE GROUNDWATER SAMPLES FROM MW 3-1, MW 3-2, MW 3-3, AND MW 3-4. COMMENCED PACKING SAMPLES.

0935 COMPLETED FILLING BRYSON TRAILER # 618CS WITH 5,000 GALLONS OF WATER AND PREPARED MANIFEST # 00941 FOR LOAD. COMMENCED LOADING BRYSON TRAILER # 429.

1000 E+E SAMPLING TEAM DEPARTED THE SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.

1030 ARRIVED AT SITE 1. THE CANSLER CREW IS IN THE PROCESS OF REMOVING THE CANOPY OVER THE EXCAVATION. CANOPY IS NOT MOVING AS A UNIT.

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1045 RETURNED TO SITE 3. ALL WATER IN THE EXCAVATION HAS BEEN REMOVED EXCEPT FOR THE ICE. BRYSON TRAILER # 429 LOADED WITH 5,300 GALLONS OF WATER. PREPARED MANIFEST # 00942 FOR LOAD. BOTH TANKERS DEPARTED THE SITE.

1100 ENVIRONICS PERSONNEL OPENED THE DRUMS OF DRILLING FLUIDS, DEVELOPMENT WATER AND PURGE WATER AND FOUND THE DRUMS FULL OF ICE. ENVIRONICS WILL CONTACT GARY SHOCKLEY AND RECOMMEND THAT THE DRUMS OF LIQUIDS BE TRANSPORTED TO OSCO FOR TREATMENT SINCE THEY CAN NOT BE BULKED.

1200 CANSLER CREW COMMENCED LOADING TRUCKS WITH STONE FROM THE SITE WEST OF THE WOODEN NICKEL.

1230 ARRIVED AT THE SITE WHERE THE STONE WAS BEING LOADED. THE FILL MATERIAL IS ALL UNDISTURBED WEATHERED BEDROCK.

1245 ARRIVED AT SITE 3. TWO LOADS OF ROCK FILL HAVE BEEN DUMPED IN THE EXCAVATION; AN ESTIMATED FOUR MORE LOADS OF STONE WILL BE NEEDED TO FILL THE EXCAVATION.

1300 ARRIVED AT SITE 1. BRYSON TRAILER # 617

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Title:	**GEOLOGIC LOGGING**
Category:	GEO 4.8
Revised:	March 1998

STANDARD OPERATING PROCEDURE

GEOLOGIC LOGGING

ecology and environment, inc.
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1. Introduction

Geologic logging involves keeping detailed records during the drilling of boreholes, the installation of monitoring wells, and the excavation of test pits, and entering the geologic descriptions of the soil and rock samples recovered on a standardized form. E & E has adapted a standardized geotechnical logbook (see DOC 2.4 in E & E's Standard Operating Procedures [SOPs]) that contains items deemed important to record when installing monitoring wells, piezometers, and/or soil borings. This document discusses general procedures for completing geologic logs.

2. Drilling Logs

2.1 Basic Documentation

When drilling boreholes, the project geologist should maintain a log that describes each borehole. The E & E Geotechnical Logbook contains records for boreholes. The following basic information should be entered on the heading of each drilling log sheet (see Figure 1):

- Borehole/well number;
- Project name;
- Site location;
- Dates and times that drilling was started and completed;
- Drilling company;
- E & E geologist's name;
- Drill rig type used to drill the borehole;
- Drilling method(s) used to drill the borehole;

DRILLING LOG FOR ______________________

Project Name ______________________

Site Location ______________________

____

Date Started/Finished ______________________

Drilling Company ______________________

Driller's Name ______________________

Geologist's Name ______________________

Geologist's Signature ______________________

Rig Type(s) ______________________

Drilling Method(s) ______________________

Bit Size(s) __________ Auger Size(s) __________

Auger/Split Spoon Refusal ______________________

Total Depth of Borehole is ______________________

Total Depth of Corehole is ______________________

Water Level (TOIC)		
Date	Time	Level (Feet)

Well Location Sketch

N

Depth (Feet)	Sample Number	Blows on Sampler	Soil Components CL SI S GR	Rock Pile	Penetration Times	Run Number	Core Recovery	RQD	Fracture Sketch	HNu/OVA (ppm)	Comments
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

Figure 1 Drilling Log

- Bit and auger size(s);
- Depth of auger/split barrel sampler refusal;
- Total depth of borehole;
- Total depth of corehole (if applicable);
- Water level at time of completion measured from top of inside casing (TOIC); and
- A well location sketch.

2.2 Technical Information

During the drilling of a borehole, specific technical information about the unconsolidated material and rock encountered should be recorded on the drilling log sheet. The following minimum technical information should be recorded:

- Depth that sample was collected or encountered;
- Sample number assigned (if applicable);
- The number of blow counts required to drive the split barrel sampler 2 feet at 6-inch intervals (see Table 1);
- Description of soil components (see Figure 2);
- Description of rock profile (see Figure 3);
- Rock qualitative designation (RQD) (see Figure 4);
- Rock penetration time;
- Core run number (if applicable) and percent recovery; and
- Organic vapor readings in the sample.

Table 1 Standard Penetration Test for Soil Density

N-Blows/Feet	Relative Density
Cohesionless Soils	
0 - 4	Very loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
50	Very dense
Cohesive Soils	
2	Very soft
2 - 4	Soft
4 - 8	Medium
8 - 15	Stiff
15 - 30	Very stiff
30	Hard

3. Soil Classification

Soils should be described using the Unified Soil Classification System (USCS) in the narrative lithologic description section of Figure 5. Figure 6 is a summary of the American Society for Testing and Materials (ASTM) criteria for describing soils. Soil descriptions should be concise, stressing major constituents and characteristics, and should be given in a consistent order and format. The following order is recommended by the ASTM:

1. Soil name. The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.

2. Gradation or Plasticity. Granular soils (i.e., sands or gravels) should be described as well-graded, poorly-graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soils (i.e., silts and clays) should be described as nonplastic, slightly plastic, moderately plastic, or highly plastic, depending on results of the manual evaluation for plasticity.

3. Particle size distribution. An estimate of the percentage and grain-size range of each subordinate constituent of the soil. This description may also include a description of angularity (see Figure 7).

4. Color. The basic color of the soil.

SOIL AND SEDIMENT CLASSIFICATION

GRAIN-SIZE SCALE (Modified Wentworth Scale)

phi	mm	inches	U.S. Standard Sieve Series	Grade Name		
-12	4096	161.30				
				very large		
-11	2048	80.60				
				large		
-10	1024	40.30			Boulders	
				medium		
-9	512	20.20				
				small		
-8	256	10.10				
				large		
-7	128	5.00			Cobbles	GRAVEL
				small		
-6	64	2.52	63.0 mm			
				very coarse		
-5	32	1.26	31.5 mm			
				coarse		
-4	16	0.63	16.0 mm		Pebbles	
				medium		
-3	8	0.32	8.0 mm			
				fine		
-2	4	0.16	No. 5			
				very fine		
-1	2	0.08	No. 10			
				very coarse		
0	1	0.04	No. 18		Sand	SAND
				coarse		
+1	0.500		No. 35			
				medium		
+2	0.250		No. 60			
				fine		
+3	0.125		No. 120			
				very fine		
+4	0.062		No. 230			
				coarse		
+5	0.031				Silt	
				medium		
+6	0.016					
				fine		
+7	0.008					MUD
				very fine		
+8	0.004					
				coarse		
+9	0.002					
				medium		
+10	0.001					
				fine		
+11	0.0005					CLAY SIZE
				very fine		
+12	0.00025					

PROPORTIONS USED IN DESCRIBING SOILS

Trace - Particles are present but estimated to be less than 5%
Few - 5 to 10%
Little - 15 to 25%
Some - 30 to 45%
Mostly - 50 to 100%

I.e.: Sand with a trace of silt = 95% Sand, < 5% Silt

(When sampling gravelly soils with a standard split spoon, the true percentage of gravel is often not recovered due to relatively small sample diameter.)

Soil Density from Standard Penetration Test (ASTM D1586)

Granular Soils	Cohesive Soils
0 - 10: Loose	0 - 4: Soft
10 - 30: Medium Dense	4 - 8: Medium Stiff
30 - 50 Dense	8 - 15: Stiff
Over 50: Very Dense	15 - 30: Very Stiff

CLASSIFICATION CHART(United Soil Classification System)

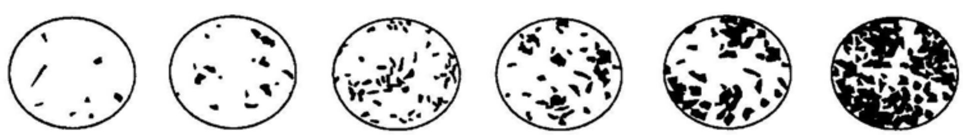
MAJOR DIVISIONS			Symbols	TYPICAL NAMES
Coarse Grained Soils	(More than 1/2 of soil > no 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels or gravel-sand mixtures little or no fines
			GM	Silty gravels, gravel-sand-silt mixture
			CC	Clayey gravels, gravel-sand-clay mixtures
		SANDS (More than 1/2 of coarse fraction < No. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
			SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand clay mixtures
Fine Grained Soils	(More than 1/2 of soil < no 200 sieve size)	SILTS AND CLAYS LL< 50	ML	Inorganic silts, and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays, of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic clays of low plasticity
		SILTS AND CLAYS LL> 50	MH	Inorganic silts, micaceous or diatamaceous, fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

Figure 2 USCS Soil Classification Chart

ROCK DESCRIPTIVE TERMS

Term		Defining Characteristics	
Hardness	Soft	Scratched by fingernail	
	Moderately Hard	Scratched easily by penknife	
	Hard	Difficult to scratch with a penknife	
	Very Hard	Cannot be scratched by penknife	
Weathering	Unweathered	Rock is unstained. May be fractured, but discontinuities are not stained.	
	Slighty	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.	
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.	
	High	Individual rock fragments are thoroughly stained and may be crumbly.	
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.	
Bedding Planes	Laminated	< .04 in.	< 1 mm
	Parting	.04 in. - .24 in.	1mm - 6mm
	Banded	.24 in. - 1in.	6 mm - 3 cm
	Thin	1 in. - 4 in.	3 cm - 9.1 cm
	Medium	4 in. - 12 in.	9.1 cm - 30.5 cm
	Thick	12 in.- 36 in.	30.5 cm - 1m
	Massive	> 36 in.	> 1 m
Joints and Fracture Spacing	Very tight	< 2 in.	< 5.1 cm
	Tight	2 in. - 1ft.	5.1 - 30.5 cm
	Moderately tight	1ft. - 3 ft.	30.5 cm - 91.4 cm
	Wide	3 ft. - 10 ft.	91.4 cm - 3 M
	Very wide	> 10 ft.	> 3 M
Voids	Porous	Smaller than a pinhead. Their presence is indicated by the degree of absorbency.	
	Pitted	Pinhead size to a 1/4 inch. If only thin walls separate the individual pits, the core may be described as honeycombed.	
	Vug	1/4 inch to the diameter of the core. The upper limit will vary with core size.	
	Cavity	Larger than the diameter of the core.	

Rock Particle Percent Composition Estimation



1% 5% 10% 15% 25% 50%

Figure 3 Rock Descriptive Terms

ROCK QUALITY DESIGNATION (RQD) AND FRACTURE FREQUENCY

Core borings are a useful means of obtaining information about the quality of rock mass. The recoverable core indicates the character of the intact rock and the number and character of the natural discontinuities.

Another quantitative index that has proved useful in logging NX core is a rock quality designation (RQD) developed by Deere (1963). The RQD is a modified core recovery percentage in which all the pieces of sound NX core over 4 inches long are counted as recovery. The length of the core run is the distance to the nearest tenth of a foot from the corrected depth of the hole at the end of the previous run to the corrected depth of the hole at the end of subject run. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. The RQD is a more general measure of the core quality than the fracture frequency. Core loss, weathered and soft zones, as well as fractures, are accounted for in this determination. The RQD provides a preliminary estimate of the variation of the in situ rock mass properties from the properties of the "sound" portion of the rock core. Thus, a general estimate of the behavior of the rock mass can be made. An RQD approaching 100 percent denotes an excellent quality rock mass with properties similar to that of an intact specimen. RQD values ranging from 0 to 50 percent are indicative of a poor quality rock mass having a small fraction of the strength and stiffness measured for an intact specimen.

RQD (Rock Quality Designation)

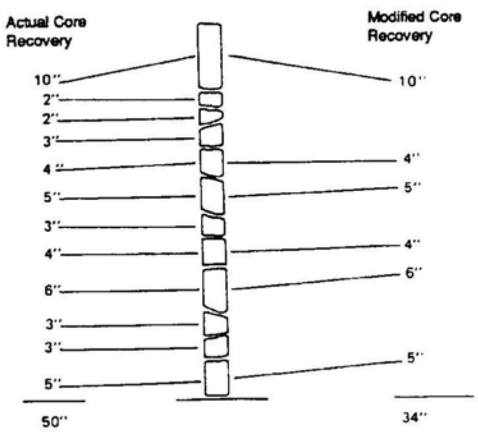
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

An example of determining the RQD from a core run of 60 inches measured from corrected depth to corrected depth is given in Diagram 1. For this particular case, the core recovery was 50 inches and the modified core recovery was 34 inches. This yields an RQD of 57 percent, classifying the rock mass in the fair category.

Problems arise in the use of RQD for determining the in situ rock mass quality. The RQD evaluates fractures in the core caused by the drilling process, as well as in natural fractures previously existing in the rock mass. For example, when the core hole penetrates a fault zone or a joint, additional breaks may form that, although not natural fractures, are caused by natural planes of weakness existing in the rock mass. These fresh breaks occur during drilling and handling of the core and are not related to the quality of the rock mass. The skill of the driller will affect the amount of breakage and the core loss that occurs. Poor drilling techniques will "penalize" the rock by lowering its apparent quality. It is difficult to distinguish between drilling breaks and those natural and incipient fractures that reflect the quality of the rock mass. In certain instances, it may be advisable to include all fractures when estimating RQD. Obviously, some judgement is involved in core logging.

Another problem with the use of the RQD index is that the determinations are not sensative to the tightness of the individual joints, whereas in some instances, the in situ deformation modulus may be strongly affected by the average joint opening.

RQD OF A SINGLE CORE RUN*

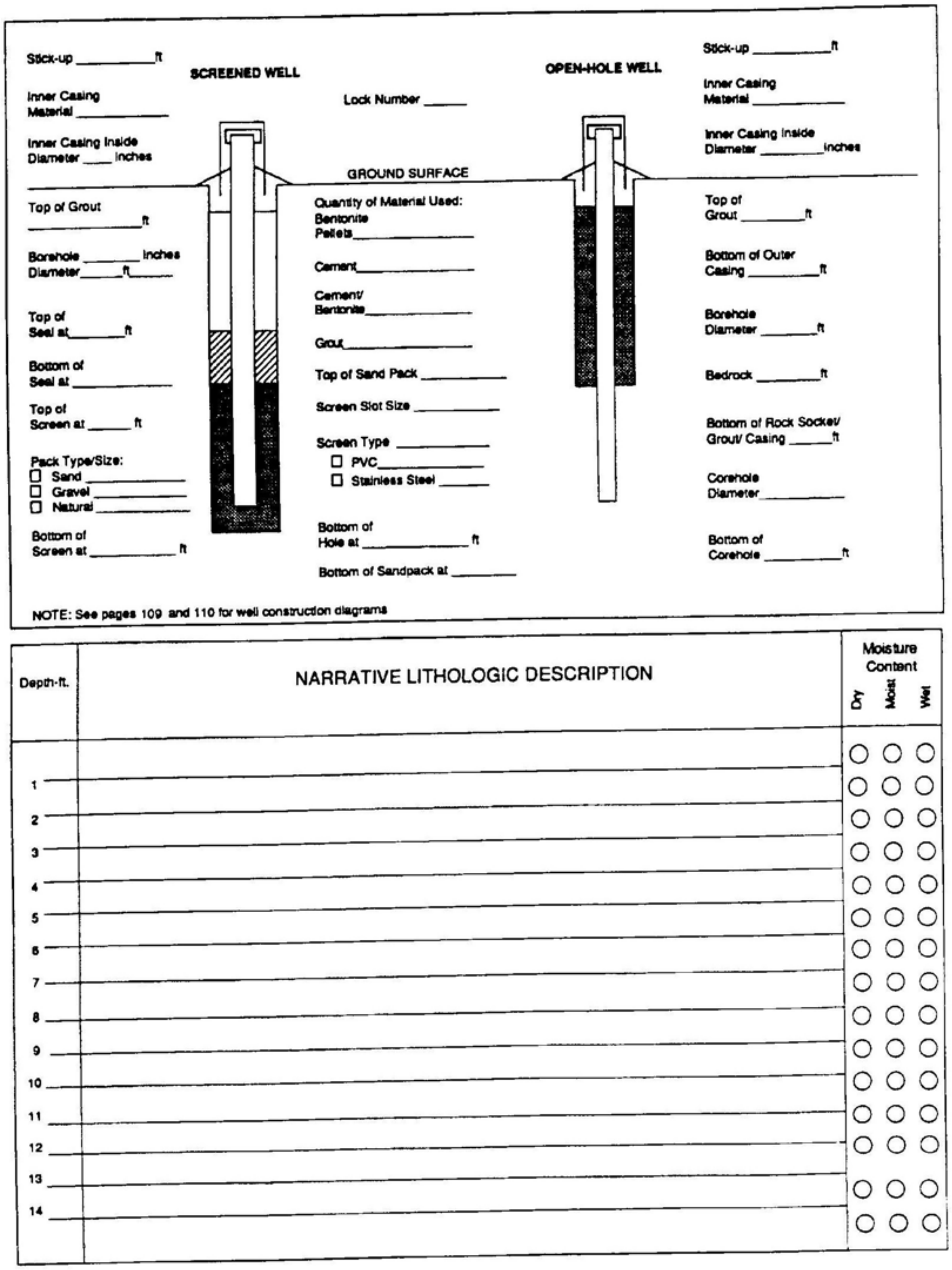


Core Run 60" (Corrected depth to corrected depth)

$\frac{34"}{60"} \times 100\% = 57\% = $ Fair

* Typical calculation of RQD of a single core run. Note that the run is calculated from corrected depth to corrected depth.

Figure 4 Rock Qualitative Designation (RQD)


Stick-up ________ ft

SCREENED WELL

Inner Casing Material ________

Lock Number _____

Inner Casing Inside Diameter ____ inches

GROUND SURFACE

Top of Grout ________ ft

Quantity of Material Used:
Bentonite Pellets________

Borehole ______ inches
Diameter_____ft_____

Cement________

Cement/ Bentonite________

Top of Seal at______ft

Grout________

Bottom of Seal at________

Top of Sand Pack ________

Top of Screen at _____ ft

Screen Slot Size ________

Pack Type/Size:
☐ Sand ________
☐ Gravel ________
☐ Natural ________

Screen Type ________
☐ PVC________
☐ Stainless Steel ______

Bottom of Screen at ________ ft

Bottom of Hole at ________ ft

Bottom of Sandpack at ________

OPEN-HOLE WELL

Stick-up ________ ft

Inner Casing Material ________

Inner Casing Inside Diameter ________ inches

Top of Grout ________ ft

Bottom of Outer Casing ________ ft

Borehole Diameter ________ ft

Bedrock ________ ft

Bottom of Rock Socket/ Grout/ Casing ______ ft

Corehole Diameter________

Bottom of Corehole ________ ft

NOTE: See pages 109 and 110 for well construction diagrams

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content Dry	Moist	Wet
		○	○	○
1		○	○	○
2		○	○	○
3		○	○	○
4		○	○	○
5		○	○	○
6		○	○	○
7		○	○	○
8		○	○	○
9		○	○	○
10		○	○	○
11		○	○	○
12		○	○	○
13		○	○	○
14		○	○	○

Figure 5 Narrative Lithologic Description

ASTM CRITERIA FOR DESCRIBING SOIL

Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane side with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved side and no edges

Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit . The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and shard surface

Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varing material or color with layers at least 6 mm thick; note thickness.
Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

Figure 6 ASTM Criteria For Describing Soil

CRITERIA FOR DESCRIBING SOIL (Cont.)

Criteria for Describing the Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Particle Shape

The particle shape shall be described as follows where length, width, and thickness refer to greatest, intermediate, and least dimensions of a particle, respectively (see page 104).

Flat	Particles with width/thickness ratio > 3
Elongated	Particles with length/width ratio > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

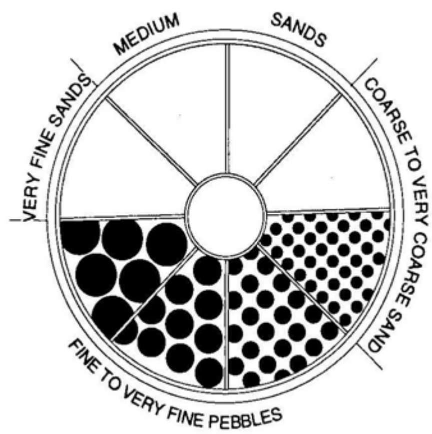
Criteria for Describing Moisture Condition

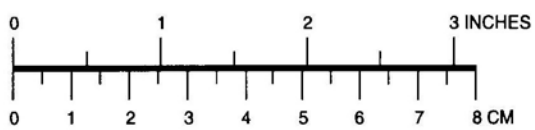
Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Figure 6 ASTM Criteria for Describing Soil (cont.)

SEDIMENT PARTICLE SIZE AND SHAPE ESTIMATES

GRAPH FOR DETERMINING SIZE OF SEDIMENTARY PARTICLES





COBBLES RANGE FROM 6.4 TO 25.6 cm (~2.5 TO 10.1 INCHES)
BOULDERS ARE LARGER THAN 25.6 cm (>10.1 INCHES)

SEDIMENT PARTICLE SHAPES

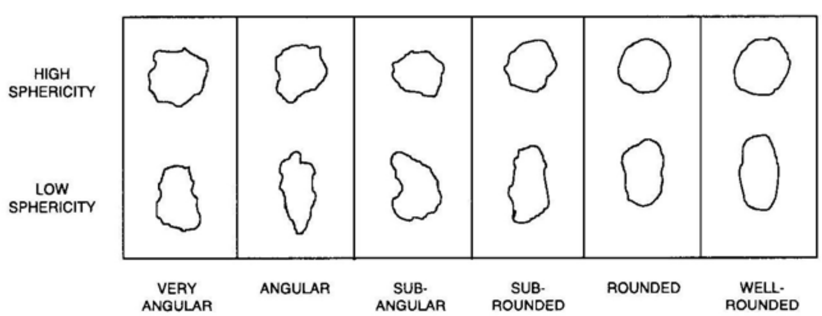


Figure 7 Sediment Particle Size and Shape Estimates

5. Moisture content. The amount of soil moisture (dry, moist, or wet).

6. Relative density or consistency. An estimate of density of a granular soil or consistency of a cohesive soil, usually based on the standard penetration test results (see Table 1).

7. Soil Structure or Mineralogy. Description of discontinuities, inclusions, and structures. Includes joints, fissures, and slickensides.

4. Core Logging

4.1 Handling of Core

After the core has been recovered from the corehole and the core barrel has been opened, the core should be placed in a core box. The top of the core should be placed at the back left corner of the core box, and the remaining core placed to the right of the preceding section (see Figure 8). The core box should be filled in this manner, moving to the front sections of the core box. The beginning of each run should be marked on the core and also noted with a marked wooden block.

4.2 Rock Description

Each stratigraphic unit in the core shall be logged. A line marking the depth of the top and the bottom of the unit shall be drawn horizontally. In classifying the rock, the geologist should avoid being too technical, as the information presented must be used by numerous people with widely divergent backgrounds.

The classification and description of each unit should be given in the following order, as applicable:

1. Unit designation (Miami oolite, Clayton Formation, Chattanooga shale);

2. Rock type;

3. Hardness;

4. Degree of weathering;

5. Texture;

6. Structure;

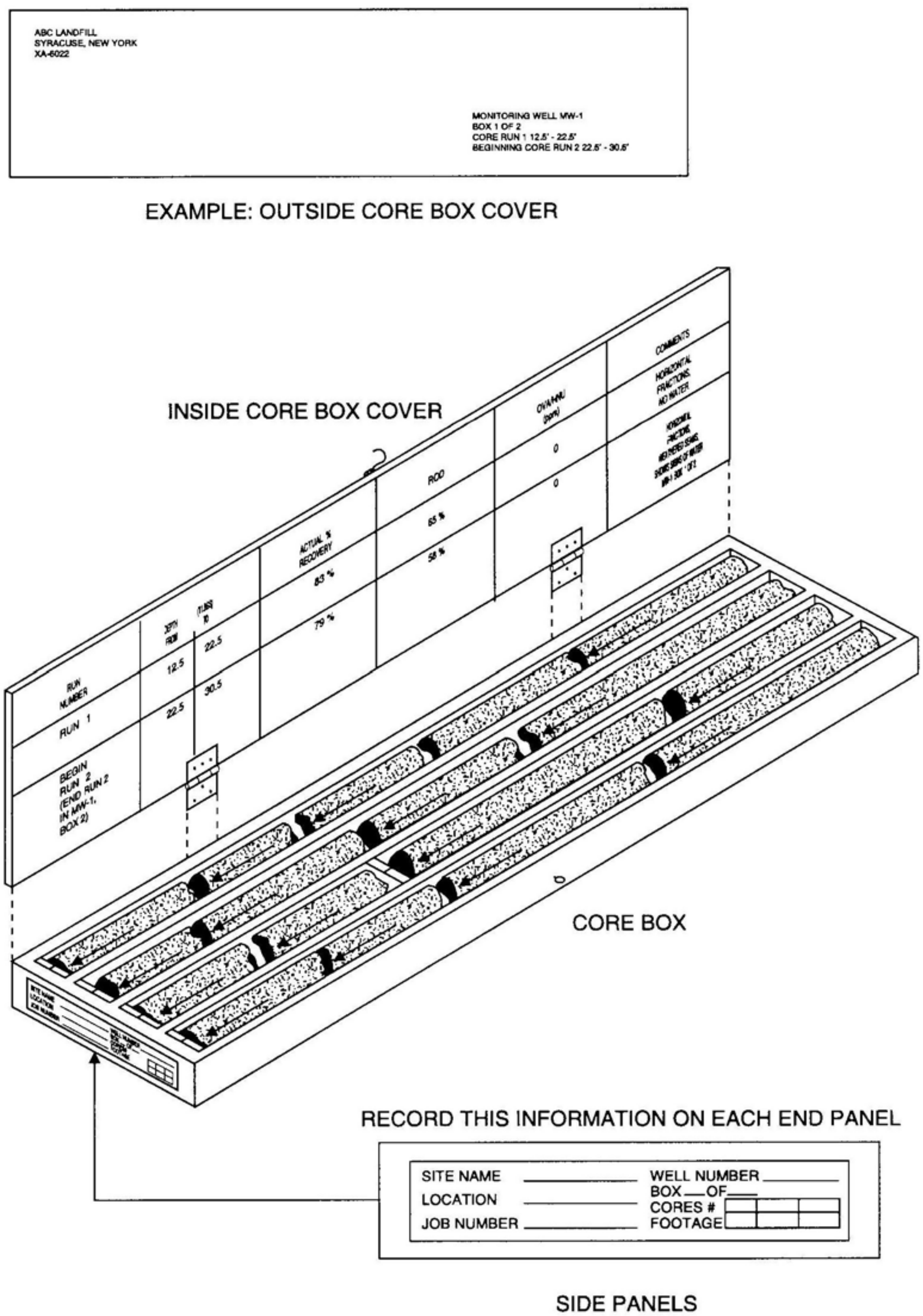


Figure 8 Core Box

7. Color;

8. Solution and void conditions;

9. Swelling properties;

10. Slaking properties; and

11. Additional description, such as mineralization, size, and spacing shale seams, etc.

Variations from the general description of the unit and features not included in the general description shall be indicated by brackets and lines to show the depth and the interval in the core where the feature exists. These variations and features shall be identified by terms that will adequately describe the feature or variation so as to delineate it from the unit. These may be zones or seams of different color, texture, etc., from that of the unit as a whole, such as staining; variations in texture; shale seams, gypsum seams, chert nodules, calcite masses, etc.; mineralized zones; vuggy zones, joints, fractures; open and/or stained bedding planes; faults, shear zones, gouge; cavities' thickness, open or filled, nature of filling, etc.; or any core left in the bottom of the hole after the final pull.

Rock Type and Lithology

1. Rock will be classified according to the following 24 types:

   - Sandstone
   - Conglomerate
   - Coal
   - Compaction Shale
   - Cemented Shale
   - Indurated Clay
   - Limestone
   - Chalk
   - Gneiss
   - Schist

- Graywacke
- Quartzite
- Dolomite
- Marble
- Soapstone and Serpentine
- Slate
- Granite
- Diorite
- Gabbro
- Rhyolite
- Andesite
- Basalt
- Tuff or Tuff Breccia
- Agglomerate or Flow Breccia

2. Lithologic characteristics should be included to differentiate rocks of the same classification. These adjectives should be simple and easily understood, such as shaly, sandy, dolomitic, etc. Inclusions, nodules, and concretions should also be noted here.

3. It is important to maintain a simple but accurate rock classification. The rock type and lithologic characteristics are essentially used to differentiate the rock units encountered.

Hardness

The terms for hardness, as outlined below, were modified to include the use of a rock hammer.

1. **Very soft** or plastic - can be deformed by hand (has a rock-like character but can be broken easily by hand).

2. **Soft** - can be scratched with a fingernail (cannot be crumbled between fingers but can be easily pitted with light blows of a geology hammer).

3. **Moderately hard** - can be scratched easily with a knife; cannot be scratched with a fingernail (can be pitted with moderate blows of a geology hammer).

4. **Hard** - difficult to scratch with a knife (cannot be pitted with a geology hammer but can be chipped with moderate blows of the hammer).

5. **Very hard** - cannot be scratched with a knife (chips can be broken off only with heavy blows of the geology hammer).

Weathering

The degree and depth of weathering is very important and should be accurately detailed in the general description and clearly indicated on the drill log.

1. **Unweathered** - no evidence of any mechanical or chemical alteration.

2. **Slightly weathered** - superficial discoloration, alteration, and/or discoloration along discontinuities; less than 10% of the rock volume is altered; strength is essentially unaffected.

3. **Moderately weathered** - discoloration is evident; surface is pitted and altered, with alterations penetrating well below rock surfaces; 10% to 50% of the rock is altered; strength is noticeably less than unweathered rock.

4. **Highly weathered** - entire section is discolored; alteration is greater than 50%; some areas of slightly weathered rock are present; some minerals are leached away; retains only a fraction of its original strength (wet strength is usually lower than dry strength).

5. **Decomposed** - saprolite; rock is essentially reduced to a soil with a relic rock texture; can be molded or crumbled by hand.

Texture

Texture is used to denote the size of the grains or crystals comprising the rock, as opposed to the arrangement of the grains or crystals, which is considered a structure.

1. **Aphanitic** - grain diameter less than 0.004 inch (0.1 mm); individual grains or crystals are too small to be seen with the naked eye.

2. **Fine-grained, finely crystalline** - grain diameter between 0.004 inch (0.1 mm) and 0.003 (1 mm); grains or crystals can be seen with the naked eye.

3. **Medium-grained, crystalline** - grain diameters between 0.003 foot (1 mm) and 0.0175 foot (5 mm).

4. **Coarse-grained, coarsely crystalline** - grain diameter greater than 0.0175 foot (5 mm).

Structure

The structural character of the rock shall be described in terms of grain or crystal alignment, bedding, and discontinuities, as applicable. The terms may be used singularly or paired.

1. **Foliation and/or lineation** - give approximate dip uniformity, degree of distinctiveness, banding, etc.

2. **Joints:**
   a. Type - bedding, cleavage, foliation, extension, etc.
   b. Degree of openness - tight or open.
   c. Surface or joint plane characteristics - smooth, rough, undulating.
   d. Weathering - degree, staining.
   e. Frequency - see (4).

3. **Fractures, shears, gouge:**
   a. Nature - single plane or zone. (Note thickness.)
   b. Character of materials in plane or zone.
   c. Slickensides.

4. **Frequency:**
   a. Intact - spacing greater than 6 feet (2 m).
   b. Slightly jointed (fractured) - spacing 3 feet (1 m) to 6 feet (2 m).
   c. Moderately jointed (fractured) - spacing 1 foot (0.3 m) to 3 feet (1 m).
   d. Highly jointed (fractured) - spacing 0.3 foot (9.1 cm) to 1 foot (0.3 m).
   e. Intensely jointed (fractured) - spacing less than 0.3 foot (9.1 cm).

5. **Bedding** is used to describe the average thickness of the individual beds within recognized unit, and the terms thick, medium, or thin should not be applied to the individual beds. "Parting" and "band" are used to describe single stratum as outlined below:
   a. Massive - over 3 feet thick (1 m).
   b. Thick - 1 foot (30.5 cm) to 3 feet (1 m) thick.
   c. Medium - 0.3 foot (9.1 cm) to 1 foot (30.5 cm) thick.
   d. Thin - 0.1 foot (3.0 cm) to 0.3 foot (9.1 cm) thick.

e. Band - 0.02 foot (6 mm) to 0.1 foot (3.0 cm) thick, described to the nearest 0.01 foot.
f. Parting - less than 0.02 foot (6 mm).
g. Paper-thin parting.

The terms and descriptions for the structure of the rock are to be used to describe the character of the rock units recognized and are not to be used as a substitute for describing individual discontinuities. Except for areas where the rock is intensely fractured or jointed, each discontinuity should be described on the log as to position, dip, staining, weathering, breccia, gouge, etc.

Color is often valuable in correlating or differentiating samples, but can be misleading or uninformative. The color of a sample should represent the sample in terms of basic hues (i.e., red, blue, gray, black), supplemented with modifying hues as required (i.e., bluish gray, mottled brown). The core should be surface wet when describing the color; if it is dry, the log should indicate "dry color." Subjective colors, such as buff or maroon, should not be used. Specific color charts, such as the Mumsel Color Chart or the Color Index in the Colorado School of Mines, Quarterly, Volume 50, No. 1, are useful in describing color of samples. When such a chart or index is used, it should be noted on the log in the remarks column.

Solution and Void Conditions shall be described in detail, as these features can affect the strength of the rock and can indicate potential seepage paths through the rock. When cavities are detected by drill action, the depth to top and bottom of the cavity should be determined by measuring the stick-up of the drill tools when the cavity is first encountered and again at the bottom, as it is very difficult to reconstruct cavities from the core alone. Filling material, when present and recovered, should be described in detail opposite the cavity. When no material is recovered from the area of the cavity, the inspector should note the probable conditions of the cavity as determined from observing the drilling action and the color of the drill fluid. If the drill action indicated material was present (i.e., slow rod drop, no loss of drill water, noticeable change in color of water return), it should be noted on the log that the cavity was probably filled and the materials should be described as best as possible from the cuttings or traces left on the core. If drill action indicates the cavity was open (i.e., no resistance to the drill tools, loss of drill fluid), this should be noted on the drill log. Partially filled cavities should also be noted. All of these observations require close observation of the drill action and water return by both the inspector and the driller; accurate measurement of stick-ups; and detailed inspection of the core. When possible, filling material should be wrapped in foil if left in the core box. If the material is to be tested or examined in the lab, it should be sealed in a jar with proper labels and a spacer, with a note showing the disposition of the material should be placed in the core box at the point from which the material was taken. Terms to describe voids encountered shall be as follows:

1. **Porous** - voids less than 0.003 foot (1 mm) in diameter.

2. **Pitted** - voids 0.03 foot (1 mm) to 0.02 foot (6 mm) in diameter.

3. **Vug** - voids 0.02 foot (6 mm) to the diameter of the core.

4. **Cavity** - voids greater than diameter of the core.

4.3 Core Labeling

The top of the core should be shown on each piece of core with an arrow written in a black, waterproof marker. The arrow will indicate which end of the core is nearer the ground surface. Other core markings may include locations of mechanical breaks and drilling footages.

4.4 Core Box Labeling

Each core box should be labeled as follows:

- On the top left corner of the outer core box, the project name, site location (city and state), and project number should be written.
- On the lower right corner of the outer core box, the corehole number (e.g., MW1, BH2), core box number (e.g., 1 of 2, 2 of 2), and the interval of the core run contained in the core box should be written.
- The side panels should be marked as indicated in Figure 8.
- The inside of the core box cover should be marked as indicated in Figure 8.

4.5 Core Storage

It is important to use proper-sized (HQ or NQ) wooden core boxes for rock core storage. After labeling the box and before closing the box for final storage or shipment, wooden spacers should be inserted into each compartment that contains rock core. This will prevent lateral movement of the cores, which could damage the rock material during handling.

After properly logging, labelling, and packing the cores, the core boxes should be stored in a dry location, preferably off of the floor on a pallet. The boxes can be stacked to a reasonable height so as not to be unstable, with end labelling facing out.

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STANDARD OPERATING PROCEDURE

GROUNDWATER WELL SAMPLING

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1. Introduction

The objective of this Standard Operating Procedures (SOP) document is to provide recommended procedures for the sampling of groundwater wells, and is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. Groundwater sampling procedures appropriate to the project objectives and site conditions will define a sampling event.

Analysis of groundwater samples may determine pollutant concentrations and its risk to public health, welfare, or the environment; extent of contaminants; and confirmation of remedial standards.

2. Scope

This document describes procedures for obtaining representative groundwater samples, quality assurance/quality control (QA/QC) measures to be followed, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Before sampling a monitoring well, the well must be purged. This may be done with a number of portable devices, including bailers, submersible pumps, bladder pumps, gas-driven pumps, gas-lift pumps, suction-lift pumps, and inertial-lift pumps. Refer to E & E Standard Operating Procedure for *Groundwater Sampling Devices* (ENV 3.6) for information on different groundwater purging and sampling devices.

A minimum of three well volumes should be removed during well purging to ensure that a representative sample of the groundwater will be sampled. Once the purging is completed and the properly prepared sample containers have been selected, sampling may proceed. Numerous types of sampling devices may be selected for the collection of the groundwater sample, but care should be taken when selecting the sampling device, as some will affect the integrity of the sample.

Sampling should occur in a progression from the least to most contaminated well, if known. Ideally, a dedicated sampling device should be used for each well. However, dedicated sampling devices may not be practical if there are a large number of groundwater samples to be collected. In this case, sampling devices should be cleaned between sampling events using the decontamination procedures outlined in E & E Standard Operating Procedure for *Equipment Decontamination* (ENV 3.15).

4. Sample Preservation, Containers, Handling, and Storage

The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering requirements (see Table 1). Chemical preservation and cooling of samples to 4 degrees Celsius only retards biological and chemical degradation of contaminants in the sample. Therefore, it is prudent to have the samples delivered to the laboratory as soon as possible following collection.

Sample containers should be precleaned in accordance with U.S. Environmental Protection Agency (EPA) standards and prelabeled, and preservatives should be placed in the containers prior to sample collection. When filling containers, never overfill or prerinse with the water sample, since oil or other substances may remain in the container. For analyses that may require filtered samples (e.g., metals and TOC), the samples should be filtered in the field using one 0.45-micrometer (μm) membrane filter per sample container prior to being preserved.

When all samples have been collected, a field data sheet and a chain-of-custody (C-O-C) form should be completed, and all pertinent data entered in the field logbook. Samples will be placed in a cooler to be maintained on ice at 4 degrees Celsius. Samples must be shipped to arrive at the designated laboratory well before their holding times are reached. It is preferable that these samples be shipped or delivered daily to the laboratory as outlined in the E & E Standard Operating Procedure for *Sample Packaging and Shipping* (ENV 3.16).

5. Potential Problems

5.1 General

The primary goal is to obtain a representative analysis of the groundwater body. The analysis can be compromised by field personnel in two primary ways: by collecting an unrepresentative sample, and by incorrect handling of the sample. There are numerous ways that foreign contaminants can be introduced into the sample, and these must be avoided by following strict sampling procedures and utilization of trained personnel.

Table 1 SW-846 Sample Holding Times, Preservation Methods, and Volume Requirements for Water Samples

Protocol Parameter	Holding Time	Minimum Volume	Container Type	Preservation
VOA	14 days from date sampled	One 40-ml vial; no air space	Two 40-ml vials	Add HC1 until pH <2 and ice to 4°C
Semi-VOA (BNAs)	7 days to extract from date sampled	One 1-L jar	1/2-gallon amber glass bottle	Ice to 4°C
PCBs	7 days to extract from date sampled	One 1-L jar	1/2-gallon amber glass bottle	Ice to 4°C
Pesticides and PCBs	7 days to extract from date sampled	One 1-L jar	1/2-gallon amber glass bottle	Ice to 4°C
Metals	6 months from date sampled	One 300-ml bottle	1-L poly bottle	Add $HN0_3$ until pH <2 and ice to 4°C
Cyanide	14 days from date sampled	One 100-ml bottle	1-L poly bottle	Add NaOH until pH >12 and ice to 4°C
Hexavalent chromium	24 hours from time sampled	One 50-ml bottle	125-ml poly bottle	Ice to 4°C
TOC	28 days from date sampled	One 10-ml bottle	125-ml poly bottle	Add H_2SO_4 until pH <2 and ice to 4°C
TOX	7 days from date sampled	One 200-ml bottle	1-L amber glass bottle	Add H_2SO_4 until pH <2 and ice to 4°C
TRPHs	28 days from date sampled	One 1-L bottle	1-L amber glass bottle	Add H_2SO_4 until pH <2 and ice to 4°C

5.2 Purging

In a nonpumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened interval will mix with the groundwater due to normal flow patterns, but the water above the screened interval will remain isolated and become stagnant. Sampling team members should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface. To safeguard against collecting nonrepresentative stagnant water in a sample, the following guidelines and techniques should be adhered to during well purging and sampling:

- As a general rule, all monitoring wells should be pumped or bailed prior to the collection of the sample. Evacuation of a minimum of one volume of water in the well casing, and preferably three to five volumes, is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample collection is not as critical. However, in all cases where the monitoring data are to be used for enforcement actions, evacuation is recommended.

- For wells that can be pumped or bailed dry, the well should be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of more than one volume of water is preferred.

- A nonrepresentative sample can also result from excessive pumping of the monitoring well. Stratification of the leachate concentrations in the groundwater formation may occur or compounds that are heavier than water may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

5.3 Materials

The material used to construct groundwater purging and sampling devices can have a significant impact on the analytical results. If practical, equipment that contacts the groundwater should be constructed from stainless steel, teflon, or glass. The use of plastic should be avoided when analyzing for organics. Table 2 discusses the advantages and disadvantages of groundwater sampling devices, and Table 3 provides a ranking of sample material compatibility under various aqueous environments.

Table 2 Advantages and Disadvantages of Various Groundwater Sampling Devices

Device	Advantages	Disadvantages
Bailer	■ The only practical limitations are size and materials ■ No power source needed ■ Portable ■ Inexpensive; it can be dedicated and hung in a well, reducing the chances of cross-contamination ■ Minimal outgassing of volatile organics while sample is in bailer ■ Readily available ■ Removes stagnant water first ■ Rapid, simple method for removing small volumes of purge water	■ Time consuming, especially for large wells ■ Transfer of sample may cause aeration
Submersible Pump	■ Portable; can be used on an unlimited number of wells ■ Relatively high pumping rate (dependent on depth and size of pump) ■ Generally very reliable; does not require priming	■ Potential for effects on analysis of trace organics ■ Heavy and cumbersome, particularly in deeper wells ■ Expensive ■ Power source needed ■ Susceptible to damage from silt or sediment ■ Impractical in low-yielding or shallow wells
Non-Gas Contact Bladder Pump	■ Maintains integrity of sample ■ Easy to use	■ Difficult to clean, although dedicated tubing and bladder may be used ■ Only useful at depths down to approximately 100 feet ■ Supply of gas for operation (bottled gas and/or compressor) is difficult to obtain and is cumbersome
Suction Pump	■ Portable, inexpensive, and readily available	■ Only useful at depths down to approximately 25 feet ■ Vacuum can cause loss of dissolved gases and volatile organics ■ Pump must be primed and vacuum is often difficult to maintain ■ May cause pH modification
Inertia Pump	■ Portable, inexpensive, and readily available ■ Rapid method for purging relatively shallow wells	■ Only useful at depths down to approximately 70 feet ■ May be time consuming to use ■ Labor-intensive ■ WaTerra pump is only effective in 2-inch diameter wells

Table 3 Relative Compatibility of Rigid Groundwater Sampling Materials

	PVC I	Galvanized Steel	Carbon Steel	Low-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

Teflon
Stainless Steel 316
Stainless Steel 304
PVC I
Low-Carbon Steel
Galvanized Steel
Carbon Steel

6. Equipment Checklist

6.1 General

- Water level indicator (e.g., electric sounder, steel tape, transducer, reflection sounder, air line, etc.);
- Depth sounder;
- Appropriate keys for well cap locks;
- Steel brush;
- Organic vapor analyzer (OVA) or photo-ionization meter (HNu);
- Oil/water interface indicator (if necessary);
- Timepiece (preferably a stopwatch);
- Logbook;
- Calculator;

- Field data sheets;
- Bottle labels;
- Chain-of-custody forms;
- Custody seals;
- Sample containers;
- Engineer's rule;
- Sharp knife (locking blade);
- Tool box (screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench, bolt cutters, etc.);
- Leather work gloves;
- Appropriate personnel protection equipment;
- 5-gallon pails;
- Plastic sheeting;
- Sealable plastic bags;
- Shipping containers;
- Packing material;
- U.S. Department of Transportation (DOT) shipping labels;
- 55-gallon 1A2 (17-H) drums (if necessary);
- Decontamination solutions;
- Tap water;
- Non-phosphate soap;
- Aluminum foil;
- Garden sprayers;

- Brushes;
- Preservatives; and
- Distilled or deionized water, as necessary.

6.2 Groundwater Sampling Devices

Bailers

- Clean decontaminated bailers of appropriate size and construction material;
- Nylon line (enough to dedicate to each well);
- Sharp knife;
- Aluminum foil (to wrap clean bailers);
- Submersible Pumps
- Pump(s);
- Adequate power supply, generator, or battery;
- 1-inch black poly vinyl chloride (PVC) coil pipe (enough to dedicate to each well);
- Hose clamps;
- Safety cable (i.e., heavy-grade nylon line);
- Tool box supplement (pipe wrenches, wire strippers, electric tape, heat shrink, hose connectors, teflon tape);
- Winch or pulley (if desired);
- Gasoline for generator;
- Flow meter with gate valve; and
- 1-inch nipples and various pipe connectors.

Bladder Pumps

- Non-gas contact bladder pump;

- Compressor or nitrogen gas bottles;
- Batteries and charger;
- Teflon tubing (enough to dedicate to each well);
- Swagelock fitting; and
- Toolbox supplement (same as submersible pump).

Suction Pump

- Pump;
- Black coil pipe tubing (enough to dedicate to each well);
- Gasoline (if required);
- Toolbox supplement (same as submersible pump);
- Various hose connectors and nipples; and
- Flow meter with gate valve.

7. Preparation

7.1 Office Preparation

- The preparation of a Site-Specific Safety Plan (SSSP) is required prior to any sampling. The SSSP must be approved and signed by the Corporate Health and Safety Officer or designee (i.e., the Regional Safety Coordinator [RSC]);

- Prepare a Site-Specific Work Plan (SSWP) to meet the data quality objectives of the project in accordance with contract requirements. Review available background information (e.g., topographic maps, hydrogeologic maps, geologic maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling method to be employed, and the type and amounts of equipment and supplies required;

    - Obtain necessary sampling and monitoring equipment (see Section 6), preclean the sampling equipment, and ensure that it is in proper working order;

    - Ensure that batteries are charged, including the OVA, HNu, pump control box, and large storage batteries;

- Locate local sources for preservatives and decontamination solutions. Review this matter with the RSC or site safety coordinator;

- Contact delivery service to confirm ability to ship all equipment and samples. Determine if shipping restrictions exist; and

- Prepare schedules and coordinate with staff, clients, and regulatory agencies, if appropriate.

7.2 Field Preparation

- Identify local suppliers of expendable sampling equipment such as ice and baggies, and overnight delivery services;

- Inspect all sampling equipment and reclean, if necessary, prior to groundwater sampling (see Table 4);

Table 4 Decontamination Solutions

Type of Hazard	Name of Solution	Remarks
Amphoteric-acids and bases	Sodium bicarbonate	5-15% aqueous solution
Inorganic acids, metal processing wastes, heavy metals	Sodium carbonate	Good water softener, 10-20% aqueous solution
Solvents and organic compounds, oily, greasy unspecified wastes	Trisodium phosphate	Good rinsing solution of detergent, 10% aqueous solution
Pesticides, fungicides, cyanides, ammonia, and other non-acidic inorganic wastes	Calcium hypochlorite	Excellent disinfectant, bleaching and oxidizing agent, 10% aqueous solution
Other Types of Decontamination Solutions		
Other Detergents and Aqueous Surfactants		
Phosphate-free laboratory detergent (Alconox, Liquinox), Pennsalt 91, Oakite, Gunk, Clorox		
Solvents		
1,1,2-Trichloroethane, H2-ethyl-hexyl acetate, pesticide-grade isopropanol/acetone/methanol/hexane, heptane (nonhydrogen bonding), alcohol, diesel fuel, naphtha, beta-propiolactone, carbon tetrachloride, 8% formalinethylene, 8% hexachloromelamine, 1,2-dichloroethane (in solution), Quadcoat		
Other Solutions		
10% nitric acid, 0.1 N/10%/20% hydrochloric acid		
Water		
Potable/tap water (demonstrated to be analyte-free), distilled water, deionized water, reagent-grade distilled and deionized water		

Source: Adapted from Devinny *et al.* 1990; Mickam *et al.* 1989.

- A general site survey should be performed prior to site entry in accordance with the SSSP followed by a site safety meeting; and

- Identify all well locations.

8. Reagents

Except for decontamination solutions and sample preservatives, there are no reagents required for these procedures. Refer to E & E Standard Operating Procedure for *Equipment Decontamination* (ENV 3.15), the SSSP, or the SSWP for proper decontamination procedures and appropriate solvents.

9. Field Sampling Procedures

9.1 Sampling Preparation

- Start at the least-contaminated well, if known;

- Remove locking well cap. Note the location of the well, time of day, and date in the field logbook or sample log;

- Remove the well cap covering the well riser;

- Test the well for volatile organic compounds (VOCs) and methane by conducting a headspace analysis with a combustible gas indicator, an OVA (for VOCs and methane), or an HNu (for VOCs). Record all readings in the field logbook;

- Lower water level measuring device into well until the surface of the water table is encountered;

- Measure the distance from the top of the water table to a reference point on the well riser or casing (e.g., top of inside casing [TOIC]) and record the distance in the field logbook;

- Lower the water level measuring device to the bottom of the well, and measure the total depth of the well using the same reference point on the well riser or casing. Record the distance in the field logbook.

- Measure the diameter of the well, and calculate the volume of water in the well by multiplying the number of feet of water by the number of gallons per foot (see Section 10);

- Determine the required volume of groundwater to be removed from the well (e.g., three well volumes or as indicated in the SSWP);

- Place plastic sheeting on the ground around the well to minimize the likelihood of contamination of sampling equipment from soil adjacent to the well; and

- Prepare the purging and sampling equipment.

9.2 Purging

The amount of flushing that a well receives prior to sample collection depends on the intent of the monitoring program, as well as the hydrogeologic conditions. Programs in which overall quality determinations of water resources are involved may require long pumping periods to obtain a sample that is representative of the groundwater. The pumped volume can be determined prior to sampling, or the well can be pumped until selected parameters (e.g., temperature, electrical conductance, pH, turbidity, etc.) have stabilized. Care must be taken not to exceed the recommended purging rate for monitoring well screens (see Table 5).

Monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water, but not enough to induce flow from other areas.

During purging, water level measurements may be taken regularly at 15- and 30-second intervals. The data may be used to compute water table or aquifer transmissivity and other hydraulic characteristics.

Information on the most commonly used groundwater purging and sampling devices can be found in E & E's SOP for Groundwater Sampling Devices (ENV 3.6).

9.2.1 Bailers

Equipment needed will include a clean decontaminated bailer, nylon line, a sharp knife, and plastic sheeting. Place the plastic sheeting around the well to prevent contact of the bailer or line with the ground. Attach the line to the bailer, and then lower the bailer until it is completely submerged. Pull the bailer out of the well; ensure that the line either falls onto the plastic sheeting or never touches the ground. Empty the bailer into a 5-gallon pail. Repeat the procedure until the required purge volume has been removed. When the 5-gallon pail is full, pour the water into a 55-gallon drum or handle as indicated in the SSWP.

Table 5 Maximum Recommended Purging Rate for Monitoring Well Screens

Screen Type	Diameter (in)	Slot (in)	Open Area (ft^2/ft)	Open Area (%)	Recommended Pumping Rate gpm/ft at 0.1 ft/s	gpm/ft at 0.07 ft/s	gpm/ft at 0.03 ft/s
PVC (machine slot)	2	0.01	0.018	3.4	0.804	0.563	0.241
	2	0.02	0.033	6.4	1.496	1.047	0.449
	2	0.025	0.042	8.0	1.870	1.309	0.561
	2	0.04	0.060	11.5	2.693	1.885	0.808
	2	0.051	0.075	14.4	3.385	2.369	1.015
	4	0.01	0.036	3.4	1.608	1.126	0.482
	4	0.02	0.067	6.4	2.992	2.094	0.898
	4	0.025	0.083	8.0	3.740	2.618	1.122
	4	0.04	0.120	11.5	5.386	3.770	1.616
	4	0.051	0.151	14.4	6.773	4.741	2.032
PVC (wound)	2	0.01	0.047	9.0	2.119	1.484	0.636
	2	0.02	0.089	17.0	3.989	2.793	1.197
	2	0.03	0.124	23.7	5.579	3.905	1.674
	2	0.04	0.156	29.7	6.981	4.887	2.094
	2	0.05	0.183	34.9	8.197	5.738	2.459
	4	0.01	0.078	7.5	3.522	2.465	1.057
	4	0.02	0.147	14.1	6.607	4.625	1.982
	4	0.03	0.208	19.9	9.350	6.545	2.805
	4	0.04	0.262	25.0	11.750	8.225	3.525
	4	0.05	0.309	29.5	13.869	9.708	4.161
Stainless Steel (wire-wound)	2	0.01	0.090	17.1	4.021	2.814	1.206
	2	0.02	0.157	30.0	7.044	4.931	2.113
	2	0.03	0.210	40.2	9.444	6.610	2.833
	2	0.04	0.253	48.4	11.376	7.963	3.413
	2	0.05	0.287	54.8	12.872	9.010	3.862
	4	0.01	0.177	16.9	7.948	5.563	2.384
	4	0.02	0.307	29.3	13.776	9.643	4.133
	4	0.03	0.410	39.1	18.388	12.872	5.517
	4	0.04	0.492	47.0	22.097	15.468	6.629
	4	0.05	0.560	53.4	25.120	17.584	7.536

9.2.2 Submersible Pumps

- Assemble the pump, hose, and safety cable;
- Lower the pump and assembly into the monitoring well to a point a few feet below the water level;
- Attach to a power source and commence purging operations;
- Using a flow meter or pail and a stopwatch, determine the flow rate and calculate the time required to remove the required volume of water from the well;
- Place the purge water in 55-gallon drums or handle as indicated in the SSWP; and
- Lower the pump by stages until it is just above the screen, and continue to purge until the required volume of water has been removed from the well. In cases where the well will not yield water at a sufficient recharge rate, pump the well dry and allow it to recover.

9.2.3 Non-Gas Contact Bladder Pumps

- Assemble the teflon tubing, pump, and charged control box;
- Procedures for purging with a bladder pump are the same as for a submersible pump (Section 9.2.2); and
- Be sure to adjust the flow rate to prevent violent jolting of the hose.

9.2.4 Suction Pumps

- Assemble the pump, tubing, and power source; and
- Procedures for purging with a suction pump are the same as for a submersible pump (Section 9.2.2).

9.3 Sampling

Groundwater samples can be obtained through the use of a number of groundwater sampling devices. Each groundwater sampling device has its advantages (and disadvantages) over other devices. Ideally, groundwater sampling devices should be completely inert, economical to manufacturer, easily cleaned for reuse, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for both well purging and sample collection. There are several other factors to consider when choosing a groundwater sampling device and care should be taken when selecting the device. Refer to E & E Standard Operating Procedure for Groundwater Sampling Devices (ENV 3.6) for additional information.

9.3.1 Bailers

- Make sure that clean plastic sheeting has been placed around the well;
- Attach a line to the bailer. If a bailer was used for purging, the same bailer and line may be used for sampling;
- Lower the bailer slowly and gently into the well, taking care not to shake the well casing or splash the bailer into the water. Lower the bailer to different points adjacent to the well screen to ensure that a representative water sample is collected;
- Slowly and gently retrieve the bailer from the well, avoiding contact with the well riser;
- Remove the cap from a sample container and place the cap on plastic sheeting or in a location where it will not be contaminated. Refer to Section 9.6 for special considerations for volatile organic analysis (VOA) samples;
- Slowly pour the water into the container;
- Filter and preserve samples as required by the SSWP. Mark the water level on the container with a pen;
- Prepare the necessary QA samples as outlined in the SSWP;
- Record sample information in the field logbook or on field data sheets, and complete the C-O-C form;
- Package samples in accordance with the SSWP; and
- Repeat this process until all groundwater samples have been collected.

9.3.2 Submersible Pumps

- Allow the monitoring well to recharge after purging, keeping the pump just above the screened interval;
- Attach a gate valve to the discharge hose, and reduce the flow rate to a manageable sampling rate;
- Prepare the sample containers;

- If no gate valve is available, discharge the sample into a clean jar and fill the sample containers from the jar;

- Complete the sampling and documentation procedures as outlined in Section 9.3.1; and

- Upon completion, remove the pump and assembly and properly decontaminate the pump prior to use in the next well. Do not reuse the discharge tubing.

9.3.3 Bladder Pump

- Allow the well to recharge after purging;

- Prepare the sample containers;

- Turn the pump on. Increase the cycle time and reduce the pressure to the minimum that will allow groundwater to come to the surface;

- Complete the sampling and documentation procedures as outlined in Section 9.3.1;

- Upon completion, remove the tubing from the well and either replace the teflon tubing and bladder with new dedicated tubing and bladder, or properly decontaminate the existing material;

- Nonfiltered groundwater samples should be collected directly from the outlet tubing into the sample containers; and

- Filtered groundwater samples should be obtained by connecting the pump outlet tubing directly to the filter unit. The pump pressure should be reduced to prevent a pressure buildup on the filter, which could damage the pump bladder.

9.3.4 Suction Pumps

- Allow the well to recharge;

- Attach a gate valve to the discharge line if the suction pump discharge rate cannot be controlled, or discharge the sample into a clean glass jar and fill the sample containers from the jar;

- Sample as outlined in Section 9.3.1; and

- Upon completion, remove the tubing and properly decontaminate the pump prior to use in the next well. Do not reuse the tubing.

9.4 Filtering

Samples being analyzed for total dissolved metals and total organic carbons (TOC) may require filtering. Two types of filters are commonly used: barrel filters and vacuum filters. A barrel filter works with a bicycle pump, which is used to build up positive pressure in the chamber containing the sample. Water is then forced through 0.45-µm filter paper into a jar. The barrel itself is filled manually.

A vacuum filter involves two chambers: the upper chamber contains the sample, and a 0.45-µm filter divides the two chambers. Using a portable vacuum pump, air is withdrawn from the lower chamber, creating a vacuum, which causes the sample to move through the filter into the lower chamber. Repeated pumping may be required to drain all of the sample into the lower chamber. If preservation of the samples is necessary, this should be done after filtering.

9.5 Post-Operation

After all samples have been collected and preserved, the sampling equipment should be properly decontaminated to prevent cross-contamination of samples.

- Decontaminate all equipment according to the SSWP;
- Replace sampling equipment in storage containers;
- Prepare groundwater samples for shipment. Check sample documentation and make sure samples are properly packed for shipment; and
- Organize field notes into a report format and transfer logging information to appropriate forms.

9.6 Special Consideration for VOA Sampling

The proper collection of a sample for dissolved VOCs requires minimal disturbance of the sample to limit volatilization and subsequent loss of volatiles from the sample.

Sample retrieval systems suitable for the valid collection of volatile organic samples include: positive-displacement bladder pumps, gear-driven submersible pumps, and syringe samplers and bailers. Field conditions and other constraints will limit the choice of appropriate systems. The principal objective is to provide a valid sample for analysis that has been subjected to the least amount of turbulence possible.

The following procedures should be followed when collecting VOA samples:

- Open the vial, set the cap in a clean place, and place the proper amount of preservatives (HCl) in the vial;
- Fill the vial to the top until a convex meniscus forms on the top of the vial. Do not overfill the vial;

- Check that the cap has not been contaminated, and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap;

- Invert the vial and tap gently. If an air bubble appears, discard the sample and begin again. It is imperative that no entrapped air remains in the sample vial;

- Place the VOA vial in a cooler, oriented so that it is lying on its side, not straight up; and

- The holding time, under most protocol parameters, for VOAs is 14 days (see Table 1). It is recommended that samples be shipped or delivered to the laboratory daily. Ensure that the samples remain at 4°C, but do not allow them to freeze.

10. Calculations

Table 6 presents the volume of water in different size casings and holes. To determine the volume of water in a well, the calculations are as follows:

$$V = Tr2(0.163)$$

where:

V = Static volume of well in gallons

T = Depth of water in well, measured in feet (determined by subtracting the static water level from the total depth of the well)

r = Inside radius of well casing, measured in inches

0.163 = A constant conversion factor for the conversion of the casing radius from inches to feet and cubic feet to gallons

Table 6 Volume of Water in Casing or Hole

Diameter of Casing or Hole (in)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth	Liter per Meter of Depth	Cubic Meters per Meter of Depth
1	0.041	0.0055	0.509	0.509×10^{-3}
1.5	0.092	0.0123	1.142	1.142×10^{-3}
2	0.163	0.0218	2.024	2.024×10^{-3}
2.5	0.255	0.0341	3.167	3.167×10^{-3}
3	0.367	0.0491	4.558	4.558×10^{-3}
3.5	0.500	0.0668	6.209	6.209×10^{-3}
4	0.653	0.0873	8.110	8.110×10^{-3}
4.5	0.826	0.1104	10.260	10.260×10^{-3}
5	1.020	0.1364	12.670	12.670×10^{-3}
5.5	1.234	0.1650	15.330	15.330×10^{-3}
6	1.469	0.1963	18.240	18.240×10^{-3}
7	2.000	0.2673	24.840	24.840×10^{-3}
8	2.611	0.3491	32.430	32.430×10^{-3}
9	3.305	0.4418	41.040	41.040×10^{-3}
10	4.080	0.5454	50.670	50.670×10^{-3}
11	4.937	0.6600	61.310	61.310×10^{-3}
12	5.875	0.7854	72.960	72.960×10^{-3}
14	8.000	1.0690	99.350	99.350×10^{-3}
16	10.440	1.3960	129.650	129.650×10^{-3}
18	13.220	1.7670	164.180	164.180×10^{-3}
20	16.320	2.1820	202.680	202.680×10^{-3}
22	19.750	2.6400	245.280	245.280×10^{-3}
24	23.500	3.1420	291.850	291.850×10^{-3}
26	27.580	3.6870	342.520	342.520×10^{-3}
28	32.000	4.2760	397.410	397.410×10^{-3}
30	36.720	4.9090	456.020	456.020×10^{-3}
32	41.780	5.5850	518.870	518.870×10^{-3}
34	47.160	6.3050	585.680	585.680×10^{-3}
36	52.880	7.0690	656.720	656.720×10^{-3}

1 Gallon = 3.785 liters
1 Meter = 3.281 feet
1 Gallon water weighs 8.33 lbs = 3.785 kilograms
1 Liter water weighs 1 kilogram = 2.205 pounds
1 Gallon per foot of depth = 12.419 liters per foot of depth
1 Gallon per meter of depth = 12.319×10^{3} cubic meters per meter of depth

11. Quality Assurance/Quality Control

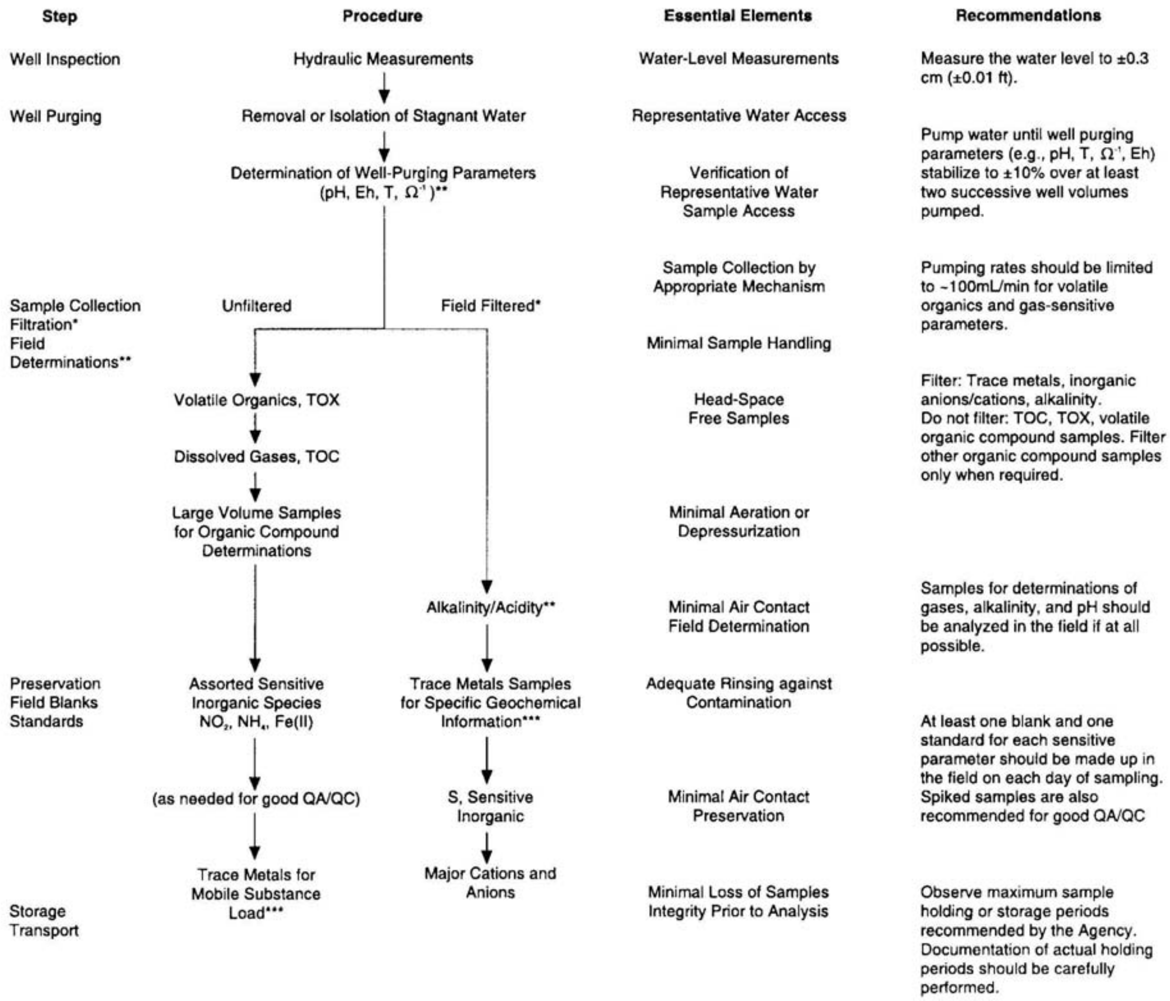
The objective of QA/QC is to identify and implement methodologies that limit the introduction of error into sampling and analytical procedures. Groundwater sampling protocols appropriate to the data quality objectives and site conditions will define the specific procedures that will be followed for sampling events (see Figure 1).

There are seven primary areas of concern for QA in the collection of representative groundwater samples:

- The SSWP should be reviewed by all team personnel involved in the collection of the groundwater samples before any sampling is attempted, with attention to contaminant type and potential concentration variations;
- Log documentation should be reviewed to determine whether the required volume of purge water was removed from the well and that the temperature, electrical conductance, and pH had been stabilized to ensure that a representative water sample of the aquifer was obtained;
- The purging and sampling devices should be made of materials and utilized in a manner that will not interact with or alter the analysis;
- The results generated by these procedures are reproducible as demonstrated through the use of duplicate samples;
- The possibility of cross-contamination is reduced by collecting samples from the least contaminated well first. Rinsate blanks should be incorporated where dedicated sampling and purging equipment is not utilized and decontamination of the equipment between sampling events is required;
- Samples are properly labeled, documented (C-O-C), preserved, and shipped; and
- A record of daily field activities, such as sample collection and tracking information, is kept in a bound book.

12. Data Validation

The data generated will be reviewed according to the QA/QC considerations presented in Section 11.



* Denotes samples that should be filtered to determine dissolved constituents. Filtration should be accomplished preferably with in-line filters and pump pressure or by N_2 pressure methods. Samples for dissolved gases or volatile organics should not be filtered. In instances where well development procedures do not allow for turbidity-free samples and may bias analytical results, split samples should be spiked with standards before filtration. Both spiked samples and regular samples should be analyzed to determine recoveries from both types of handling.

** Denotes analytical determinations that should be made in the field.

See Puls and Barcelona (1989).

Figure 1 Generalized Flow Diagram of Groundwater Sampling Protocol

13. Health and Safety

Depending on the site-specific contaminants, the type of personnel protective equipment (PPE) used during the purging and sampling of the wells is outlined in the SSSP. The SSSP should be reviewed with specific emphasis placed on the safety procedures to be followed for the well sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and protective clothing.

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STANDARD OPERATING PROCEDURE

SAMPLING EQUIPMENT DECONTAMINATION

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1. Scope and Application

The purpose of this procedure is to provide a description of methods for preventing or reducing cross-contamination and general guidelines for designing and selecting decontamination procedures for use at potential hazardous waste sites. The decontamination procedures chosen will prevent introduction and cross-contamination of suspected contaminants in environmental samples, and will protect the health and safety of site personnel.

2. Method Summary

Removing or neutralizing contaminants that have accumulated on personnel and equipment ensures protection of personnel from permeating substances, reduces/eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample contamination.

Cross-contamination can be removed by physical decontamination procedures. The abrasive and non-abrasive methods include the use of brushes, high pressure water, air and wet blasting, and high pressure Freon cleaning. These methods should be followed by a wash/rinse process using appropriate cleaning solutions. A general protocol for cleaning with solutions is as follows:

1. Physical removal.
2. Non-phosphate detergent plus tap water.
3. Tap water.
4. 10% nitric acid.
5. Distilled/deionized water rinse.
6. Solvent rinse.
7. Total air dry.
8. Triple rinse with distilled/deionized water.

This procedure can be expanded to include additional or alternate solvent rinses that will remove specified target compounds if required by site-specific work plans (WP) or as directed by a particular client.

3. Interferences

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte-free distilled/deionized water. Distilled water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Contaminant-free deionized water is available from commercial vendors and may be shipped directly to the site or your hotel.

The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system.

4. Equipment/Apparatus

The following are standard materials and equipment used as a part of the decontamination process:

- Appropriate protective clothing;
- Air purifying respirator (APR);
- Field log book;
- Non-phosphate detergent;
- Selected high purity, contaminant-free solvents;
- Long-handled brushes;
- Drop cloths (plastic sheeting);
- Trash containers;
- Paper towels;
- Galvanized tubs or equivalent (e.g., baby pools);
- Tap water;
- Contaminant-free distilled/deionized water;
- Metal/plastic container for storage and disposal of contaminated wash solutions;
- Pressurized sprayers, H_2O;
- Pressurized sprayers, solvents;
- Trash bags;
- Aluminum foil;
- Sample containers;

- Safety glasses or splash shield; and
- Emergency eyewash bottle.

5. Reagents

There are no reagents used in this procedure aside from decontamination solutions used for the equipment. The type of decontamination solution to be used shall depend upon the type and degree of contamination present and as specified in the project/site-specific Quality Assurance Project Plan (QAPP).

In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid wash (reagent grade nitric acid diluted with deionized/distilled water – 1 part acid to 10 parts water)[a];
- Acetone (pesticide grade)[b] ;
- Hexane (pesticide grade)[b];
- Methanol; and
- Methylene chloride[b].

[a] Only if sample is to be analyzed for trace metals.
[b] Only if sample is to be analyzed for organics requiring specific or specialized decontamination procedures. These solvents must be kept away from samples in order to avoid contamination by decon solvents.

6. Procedures

Decontamination is the process of removing or neutralizing contaminants that have accumulated on both personnel and equipment. Specific procedures in each case are designed accordingly and may be identified in either the Health and Safety Plan (HSP), WP, QAPP, or all three.

As part of the HSP, a personnel decontamination plan should be developed and set up before any personnel or equipment enters the areas of potential contamination. Decontamination procedures for equipment will be specified in the WP and the associated QAPP. These plans should include:

- Number and layout of decontamination stations;
- Decontamination equipment needed (see Section 4);

- Appropriate decontamination methods;
- Procedures to prevent contamination of clean areas;
- Methods and procedures to minimize worker contact with contaminants during removal of protective clothing;
- Methods and procedures to prevent cross-contamination of samples and maintain sample integrity and sample custody; and
- Methods for disposal of contaminated clothing, equipment, and solutions.

Revisions to these plans may be necessary for health and safety when the types of protective clothing, site conditions, or on-site hazards are reassessed based on new information.

Prevention of Contamination

Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

- Employing work practices that minimize contact with hazardous substances (e.g., avoid areas of obvious contamination, avoid touching potentially hazardous substances);
- Use of remote sampling, handling, and container-opening techniques;
- Covering monitoring and sampling equipment with plastic or other protective material;
- Use of disposable outer garments and disposable sampling equipment with proper containment of these disposable items;
- Use of disposable towels to clean the outer surfaces of sample bottles before and after sample collection; and
- Encasing the source of contaminants with plastic sheeting or overpacks.

Proper procedures for dressing prior to entrance into contaminated areas will minimize the potential for contaminants to bypass the protective clothing. Generally, all fasteners (zippers, buttons, snaps, etc.) should be used, gloves and boots tucked under or over sleeves and pant legs, and all junctures taped (see the Health and Safety Plan for these procedures).

Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated to remove any chemicals or infectious organisms that may have adhered to them. Various decontamination methods will either physically remove, inactivate by chemical detoxification/disinfection/sterilization, or remove contaminants by both physical and chemical means.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods.

6.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following reviews the available abrasive methods.

Mechanical

Mechanical methods include using brushes with metal, nylon, or natural bristles. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushing, and degree of brush contact. Material may also be removed by using appropriate tools to scrape, pry, or otherwise remove adhered materials.

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, and time of air blasting dictate cleaning efficiency. The method's disadvantages are its inability to control the exact amount of material removed and its large amount of waste generated.

Wet Blasting

Wet blast cleaning involves the use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using very fine abrasives, the amount of materials removed can be carefully controlled.

6.2 Non-abrasive Cleaning Methods

Non-abrasive cleaning methods work by either dissolution or by forcing the contaminant off a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods.

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and high-pressure hose. Operating pressure usually ranges from 340 to 680 psi, which relates to flow rates of 20 to 140 lpm.

Steam Cleaning

This method uses water delivered at high pressure and high temperature in order to remove accumulated solids and/or oils.

Ultra-High-Pressure Water

This system produces a water jet from 1,000 to 4,000 atm. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 m/sec. (1,000 atm) to 900 m/sec. (4,000 atm). Additives can be used to enhance the cleaning action, if approved by the QAPP for the project.

High-Pressure Freon Cleaning

Freon cleaning is a very effective method for cleaning cloth, rubber, plastic, and external/internal metal surfaces. Freon 113 (trichlorotriflorethane) is dense, chemically stable, relatively non-toxic, and leaves no residue. The vapor is easily removed from the air by activated charcoal. A high pressure (1,000 atm) jet of liquid Freon 113 is directed onto the surface to be cleaned. The Freon can be collected in a sump, filtered, and reused.

Physical removal of gross contamination should be followed by a wash/rinse process using cleaning solutions. One or more of the following methods utilize cleaning solutions.

Dissolving

Removal of surface contaminants can be accomplished by chemically dissolving them, although the solvent must be compatible with the equipment and protective clothing. Organic solvents include alcohols, ethers, ketones, aromatics, straight-chain alkanes, and common petroleum products. Halogenated solvents are generally incompatible with protective clothing and are toxic. Table 1 provides a general guide to the solubility of contaminant categories in four types of solvents.

Surfactants

Surfactants reduce adhesion forces between contaminants and the surface being cleaned and prevents reposition of the contaminants. Non-phosphate detergents dissolved in tap water is an acceptable surfactant solution.

Rinsing

Contaminants are removed and rinsing through dilution, physical attraction, and solubilization.

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment and personal protective clothing.

6.3 Field Sampling Equipment Cleaning Procedures

The following steps for equipment cleaning should be followed for general field sampling activities.

1. Physical removal (abrasive or non-abrasive methods).
2. Scrub with non-phosphate detergent plus tap water.
3. Tap water rinse.
4. 10% nitric acid (required during sampling for inorganics only).
5. Distilled/deionized water rinse.
6. Solvent rinse (required during sampling for organics only).
7. Total air dry (required during sampling for organics only).
8. Triple rinse with distilled/deionized water.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air-dried and triple-rinsed with distilled/deionized water.

Solvent rinses are not necessarily required when organics are not a contaminant of concern. Similarly, an acid rinse is not necessarily required if analysis does not include inorganics.

NOTE: Reference the appropriate analytical procedure for specific decontamination solutions required for adequate removal of the contaminants of concern.

Sampling equipment that requires the use of plastic or teflon tubing should be disassembled, cleaned, and the tubing replaced with clean tubing, if necessary, before commencement of sampling or between sampling locations.

Table 1 Decontamination Solvents

Solvent	Soluble Contaminants
Water	Low-chain compounds Salts Some organic acids and other polar compounds
Dilute Bases For example: ■ detergent ■ soap	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents: For example: ■ alcohols (methanol) ■ ethers ■ ketones ■ aromatics ■ straight-chain alkanes (e.g., hexane) ■ common petroleum products (e.g., fuel oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)

WARNING: Some organic solvents can permeate and/or degrade the protective clothing.

7. Quality Assurance/Quality Control

QA/QC samples are intended to provide information concerning possible cross-contamination during collection, handling, preparation, and packing of samples from field locations for subsequent review and interpretation. A field blank (rinsate blank) provides an additional check on possible sources of contamination from ambient air and from sampling instruments used to collect and transfer samples into sample containers.

A field blank (rinsate blank) consists of a sample of analyte-free water passed through/over a precleaned/decontaminated sampling device and placed in a clean area to attempt to simulate a worst-case condition regarding ambient air contributions to sample contamination.

Field blanks should be collected at a rate of one per day per sample matrix even if samples are not shipped that day. The field blanks should return to the lab with the trip blanks originally sent to the field and be packed with their associated matrix.

The field blank places a mechanism of control on equipment decontamination, sample handling, storage, and shipment procedures. It is also indicative of ambient conditions and/or equipment conditions that may affect the quality of the samples.

Holding times for field blanks analyzed by CLP methods begin when the blank is received in the laboratory (as documented on the chain of parameters and associated analytical methods).

Holding times for samples and blanks analyzed by SW-846 or the 600 and 500 series begins at the time of sample collection.

8. Health and Safety

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods (i.e., the method may react with contaminants to produce heat, explosion, or toxic products). Decontamination methods may be incompatible with clothing or equipment (e.g., some solvents can permeate and/or degrade protective clothing). Also, a direct health hazard to workers can be posed from chemical decontamination solutions that may be hazardous if inhaled or may be flammable.

The decontamination solutions must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods do pose a direct health hazard, measures should be taken to protect personnel or modified to eliminate the hazard.

All site-specific safety procedures should be followed for the cleaning operation. At a minimum, the following precautions should be taken:

1. Safety glasses with splash shields or goggles, neoprene gloves, and laboratory apron should be worn.

2. All solvent rinsing operations should be conducted under a fume hood or in open air.

3. No eating, smoking, drinking, chewing, or any hand-to-mouth contact is permitted.

9. References

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, 1988.

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STANDARD OPERATING PROCEDURE

SEDIMENT SAMPLING

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1. Introduction

This Standard Operating Procedure (SOP) describes the procedures for the collection of representative sediment samples. Analysis of sediment samples may determine whether concentrations of specific pollutants exceed established threshold action levels, and whether the concentrations of pollutants present a risk to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Sediment samples may be recovered using a variety of methods and equipment. These are dependent on 1) the depth of the water in which the samples will be collected; 2) the sediment's characteristics; 3) the volume of sediment required; and 4) the type of sample required (disturbed or undisturbed). Ultimately, the type of sampling device used should be consistent with the objective of the study.

Near-surface sediment samples may be collected using a scoop or spoon (if near shore or in shallow water), or sediment dredge or grab sampler (if in deeper water). To obtain other than surficial sediment samples, core samplers or split-spoon samplers are required.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, rinsed with distilled water, wrapped in aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until needed. Each sampler should be used for one sample only. However, dedicated samplers may be impractical if there are a large number of sediment samples to be collected. In this case, samplers should be cleaned in the field using the decontamination procedures outlined in E & E's *Equipment Decontamination* SOP.

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of sediments is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time. Sediment samples should be handled according to standard techniques and project-specific requirements as detailed in project work/sampling plans and quality assurance project plans.

5. Potential Problems

Potential problems with sediment sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems may be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then proper decontamination of sampling equipment is necessary. Improper sample collection can involve using inadequate or inappropriate sampling devices, contaminated equipment, disturbance of the matrix resulting in compaction of the sample, and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results.

6. Equipment

The following is a list of equipment and items typically used for sediment sampling:

- Sampling plan,
- Sample location map,
- Safety equipment, as specified in the health and safety plan,
- Compass,
- Survey equipment,
- Tape measure,
- Camera,
- Four-ounce and eight-ounce glass jars with teflon liners,

- 40-ml glass vials with teflon-backed septum,
- Plastic bags for sample jars,
- Logbook,
- Labels,
- Waterproof ink pen,
- Chain-of-custody forms,
- Shipping cooler,
- Decontamination supplies and equipment, as described in the work plan,
- Canvas or plastic sheeting,
- Stainless-steel scoops,
- Stainless-steel spoons,
- Stainless-steel mixing bowls, or pans,
- Hand-driven split-spoon sampler,
- Shovel,
- Stainless-steel hand auger,
- Sediment dredge/grab sampler,
- Manual, gravity, or mechanical coring devices, and
- Teflon beaker attached to a telescoping pole.

7. Reagents

Sediment sampling does not require the use of reagents except for decontamination of equipment. Refer to E & E's *Equipment Decontamination* SOP and the site-specific work plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

- Prepare a sampling plan in accordance with contract requirements. Conduct a literature and information search and review available background information (e.g., topographic maps, soil survey maps, geological survey maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling methods to be employed, and the type and amounts of equipment and supplies required.

- E & E corporate policy requires that a health and safety plan be prepared prior to commencing any sampling activity. The plan must be approved and signed by the corporate health and safety officer or his/her designee (e.g., the regional safety coordinator [RSC]).

- Obtain necessary sampling and monitoring equipment (see Section 6), and ensure that everything is in working order.

- Contact delivery service to confirm ability to ship all equipment and samples. Determine whether shipping restrictions exist.

- Prepare schedules and coordinate with staff, clients, property owners, and regulatory agencies, if appropriate.

8.2 Field Preparation

- Identify local suppliers of sampling expendables and overnight delivery services (e.g., Federal Express).

- Decontaminate or preclean all equipment before sediment sampling, as described in E & E's *Equipment Decontamination* SOP, or as deemed necessary.

- Calibrate all health & safety monitoring equipment daily.

- A general site survey should be performed prior to site entry, in accordance with the health and safety plan. A site safety meeting identifying physical and chemical hazards should be conducted prior to sampling activities.

- Identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All locations must be cleared of utilities by the property owner or utility companies prior to sediment sampling.

8.3 Sample Collection

Numerous techniques and sampling devices may be employed to collect representative sediment samples. A number of sampling-related factors can contribute to the loss of sample integrity, including washout of fine-grained sediments during retrieval; compaction due to sample wall friction; and sampling vessel- or person-induced disturbance of surficial layers. Choosing the most appropriate sediment sampler for a study will depend on the sediment's characteristics, the volume and efficiency required, and the objectives of the study.

Most samples will be grab samples, although occasionally, sediment taken from various locations may be combined into one composite sample to reduce the amount of analytical support required.

The following procedure is used to collect surface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location furthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating down to unsampled locations. This technique will also reduce the chances of cross-contaminating subsequent samples by sampling first in areas of suspected low contamination and working to the suspected higher concentration areas.

2. Using a precleaned, stainless-steel scoop, spoon, or other appropriate device, remove the required volume of sediment from the desired surface interval (e.g., 0-inch to 6-inch), place the sample in the appropriate precleaned glass jar, decant excess liquid as necessary, and secure the teflon-lined lid to the jar. If the sample is to be a composite sample, or if the sample is to be homogenized, the sediment is first placed in a stainless-steel mixing bowl and is homogenized prior to placement in the glass sample container. Samples for volatile organic analysis are not homogenized. Samples are handled in accordance with project-specific requirements.

3. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, secure the seal in place with clear tape, and refrigerate the sample. The clear tape should also cover the jar's label.

4. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

5. In the field logbook record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements.

6. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect subsurface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating downstream to unsampled locations, and will also reduce the chances of cross-contaminating subsequent samples.

2. Using a precleaned split-spoon sampler or other hollow coring device, drive the sampler to the required depth with a smooth continuous motion. Remove the coring device by rotating and lifting it in a single smooth motion until the sampler is free from the sediment.

3. Before the sediment sample can be removed from the sampling device, the overlying water must be removed from the sampler by slowly pouring or siphoning it off near one side of the sampler. Care should be taken to ensure that the sediments are not disturbed, and that the fine-grained surficial sediment and organic matter are not lost while removing the overlying water.

4. Disassemble the split-spoon sampler by placing pipe wrenches on either end of the sampler. Remove both ends and open the split spoon with a precleaned stainless-steel spoon. Recover the sediment core from a core tube by pushing the sample out with a precleaned stainless-steel spoon.

5. Collect the necessary sample by cutting the core with the handle of a precleaned stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.

6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.

7. Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

9. Decontaminate sampling equipment as per E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect surface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.

2. Using a precleaned sediment dredge or grab sampler, lower the sampler to the sediment layer with a polypropylene rope. Depending on the type of sampler used, the jaws of the sediment dredge will either automatically close, or will be triggered with a weighted messenger.

3. Recover the sampler and empty the sediment sample into a precleaned stainless-steel bowl. The water layer should be decanted slowly until only sediment remains in the bowl.

4. Using a precleaned stainless-steel spoon, remove the required volume of sediment. Place the sample in the appropriate precleaned glass jar, and secure the Teflon-lined lid to the jar.

5. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape. The clear tape should cover the sample label.

6. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

7. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

8. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect subsurface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.

2. Attach a precleaned gravity or mechanical coring device to the required length of polypropylene sample line and allow the corer to freefall through the water to the bottom.

3. Determine the depth of sediment penetration, and if acceptable, retrieve the corer with a smooth, continuous lifting motion.

4. Remove the overlying water from the corer by slowly pouring or siphoning it off near one side of the sampler. Remove the nosepiece from the corer, and slide the sample out of the corer into a stainless-steel bowl or tray.

5. Collect the necessary sample by cutting the core with the handle of a stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.

6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.

7. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

9. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

8.4 Postoperations

1. Decontaminate all equipment according to E & E's *Equipment Decontamination* SOP prior to shipping the equipment back to the warehouse.

2. Organize field notes into the report format required by E & E's *Field Report Preparation* SOP. Logbooks should be maintained according to E & E's *Field Activities Log Book* SOP.

3. All samples should be shipped on the same day that they were collected to arrive at the laboratory not more than 24 hours after the samples were collected in accordance with E & E's *Sample Packaging* SOP.

9. Calculations

There are no specific calculations required for sediment sampling.

10. Quality Assurance

10.1 Sample Documentation

10.1.1 Sediment Sample Label

All sediment samples shall be documented in accordance with standard labeling techniques and project-specific requirements. The sediment sample label is completed to the fullest possible extent, prior to collecting the sample, and should contain the following minimum information:

- Site name or identification;
- Sample location and identifier;
- Date sample was collected in a day, month, year format (e.g., 03 JUN 91 for June 3, 1991);
- Time of sample collection, using 24-hour clock in the hours: minutes format; and
- Analysis required.

10.1.2 Logbook

A bound field logbook will be maintained by field personnel to record daily activities in accordance with E & E's *Field Activities Logbooks* SOP and include sample collection, tracking, and shipping information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete description of the location from which the sediment sample was collected.

10.1.3 Chain-of-Custody

Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

10.2 Sampling Plan Design

- Many of the activities critical to ensuring that the collected samples are of high quality take place in the pre-collection planning and preparation stage. Careful planning and attention to detail at this stage will result in a more successful sampling effort, and will ensure collection of the highest quality samples possible. Since site and sampling conditions vary widely, and no universal sampling procedure can be recommended, a detailed sampling plan, consistent with the objectives of the study, must be developed prior to any sampling activities.

- Any of the sampling methods described here should allow a representative sediment sample to be obtained if the sampling plan is properly designed.

- Consideration must also be given to the collection of a sample representative of all horizons present in the sediment. Selection of the proper sampling device will facilitate this procedure.

- A stringent quality assurance project plan (QAPP) should be outlined before any sampling operation is attempted. This should include, but not be limited to, the use of properly cleaned samplers and sample containers, chain-of-custody procedures, and collection of quality assurance samples such as field blanks, trip blanks, and duplicate samples.

11. Data Validation

The data generated will be reviewed according to quality assurance (QA) considerations identified in Section 10.

12. Health and Safety

Depending on site-specific contaminants, various protective programs must be implemented prior to sediment sampling. The site safety plan should be reviewed with specific emphasis placed on a protection program planned for direct contact tasks. Standard safe operating practices should be followed, including minimizing contact with potential contaminants in both vapor and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

Particulate or Metals Contaminants

- Avoid skin contact with and incidental ingestion of dust. Wash hands and other exposed skin areas routinely.
- Use protective gloves when collecting and handling the sediment samples.

Volatile Organic Contaminants

- Hexane acts as a carrier for a number of semivolatile organic compounds. The presence of hexane vapors in the air while decontaminating samplers indicates that the potential for exposure exists.
- If monitoring results indicate the presence of organic vapors, sampling activities must be conducted in Level C protection.
- Acetone can penetrate some types of surgical gloves; use the appropriate gloves, such as Scorpio neoprene gloves, when handling acetone.

13. References

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STANDARD OPERATING PROCEDURE

SOIL SAMPLING

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1. Introduction

This document describes the procedures for the collection of representative soil samples. Representative sampling ensures the accurate characterization of site conditions. Analysis of soil samples may determine pollutant concentrations and the accompanying risks to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance/quality control (QA/QC) measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Soil samples may be recovered using a variety of methods and equipment. These are dependent on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type.

Samples of near-surface soils may be easily obtained using a spade, stainless-steel spoon, trowel, or scoop. Sampling at greater depths may be performed using a hand auger; a power auger; or, if a test pit is required, a backhoe.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, then wrapped in clean aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until it is needed. Each sampler should be used for one sample only. However, dedicated tools may be impractical if there is a large number of soil samples required. In this case, samplers should be cleaned in the field using standard decontamination procedures as outlined in E & E’s Standard Operating Procedure (SOP) for Sampling Equipment Decontamination (see ENV 3.15).

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of solids is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time.

Soil samples should be handled according to the procedures outlined in E & E’s SOP for Sample Packaging (see ENV 3.16).

5. Potential Problems

Potential problems with soil sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection is generally the result of the use of contaminated equipment; the disturbance of the matrix, resulting in compaction of the sample; and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results. Specific advantages and disadvantages of soil sampling equipment are presented in Table 5-1.

Table 5-1 Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Trier	Soft surface soil	Inexpensive; easy to use and decontaminate; difficult to use in stony, dry, or sandy soil.
Scoop, trowel, spoon, or spatula	Soft surface soil	Inexpensive; easy to use and decontaminate; trowels with painted surfaces should be avoided.
Tulip bulb planter	Soft soil, 0 to 6 inches	Easy to use and decontaminate; uniform diameter and sample volume; preserves soil core (suitable for volatile organic analysis (VOA) and undisturbed sample collection); limited depth capability; not useful for hard soils.
Spade or shovel	Medium soil, 0 to 12 inches	Easy to use and decontaminate; inexpensive; can result in sample mixing and loss of volatile organic compounds (VOCs).
Vehimeyer soil outfit	Soil, 0 to 10 feet	Difficult to drive into dense or hard material; can be difficult to pull from ground.
Soil coring device and auger	Soft soil, 0 to 24 inches	Relatively easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; can be difficult to decontaminate.
Thin-walled tube sampler	Soft soil, 0 to 10 feet	Easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); may be used to help maintain integrity of VOA samples; easy to decontaminate; can be difficult to remove cores from sampler.
Split-spoon sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); acetate sleeve may be used to help maintain integrity of VOA samples; useful for hard soils; often used in conjunction with drill rig for obtaining deep cores.

Table 5-1 Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Shelby tube sampler	Soft soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); tube may be used to ship sample to lab undisturbed; may be used in conjunction with drill rig for obtaining deep cores and for permeability testing; not durable in rocky soils.
Laskey sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil cores; used in conjunction with drill rig for obtaining deep core; can be difficult to decontaminate.
Bucket auger	Soft soil, 3 inches to 10 feet	Easy to use; good depth range; uniform diameter and sample volume; acetate sleeve may be used to help maintain integrity of VOA samples; may disrupt and mix soil horizons greater than 6 inches in thickness.
Hand-operated power auger	Soil, 6 inches to 15 feet	Good depth range; generally used in conjunction with bucket auger for sample collection; destroys soil core (unsuitable for VOA and undisturbed sample collection); requires two or more equipment operators; can be difficult to decontaminate; requires gasoline-powered engine (potential for cross-contamination).
Continuous-flight auger	Soil, 0 inches to bedrock	Excellent depth range; easy to decontaminate; can be used on all soil samples; results in soil mixing and loss of VOCs.
Dutch auger	Designed specifically for wet, fibrous, or rooted soils (e.g., marshes)	
Eijkelcamp stoney soil auger	Stoney soils and asphalt	
Backhoe	Soil, 0 inches to 10 feet	Good depth range; provides visual indications as to depth of contaminants; allows for recovery of samples at specific depths; can result in loss of VOCs and soil mixing; shoring required at depth.

Note: Samplers may not be suitable for soils with coarse fragments.
Augers are suitable for soils with limited coarse fragments; only the stoney auger will work well in very gravelly soil.

6. Soil Sampling Equipment

Soil Sampling Equipment List

- Stainless-steel spoon
- Trier
- Scoop
- Trowel

- Spatula
- Stainless-steel tulip bulb planter
- Spade or shovel
- Vehimeyer soil sampler outfit
  - tubes
  - points
  - drive head
  - drop hammer
  - fuller jack and grip
- Soil-coring device
- Thin-walled tube sampler
- Split-spoon sampler
- Shelby tube sampler
- Laskey sampler
- Bucket auger
- Hand-operated power auger
- Continuous-flight auger
- Dutch auger
- Eijkelcamp stoney soil auger
- Backhoe
- Hand auger with replaceable sleeves

Sampling Support Equipment and Documentation List

- Sampling plan
- Sample location map
- Safety equipment, as specified in the Health and Safety Plan
- Decontamination supplies and equipment, as described in the Work Plan
- Compass
- Tape measure
- Survey stakes or flags
- Camera
- Stainless-steel buckets or bowls
- Sample containers, precleaned (e.g., I-Chem)
- Logbook
- Chain-of-custody forms
- Plastic sheet
- Soil gas probes
- Infiltrometer
- Pounding sleeve
- Extension rods
- T-handle

Labeling, Packaging, and Shipping Supplies

- Coolers
- Labels for sample containers and coolers (e.g., "fragile")
- Ice
- Plastic bags for sample containers and ice
- ESC paint cans and clamps for polychlorinated biphenyl sampling
- Vermiculite
- Duct and strapping tape
- Federal Express airbills and pouches

6.1 Geophysical Equipment

Geophysical techniques can be integrated with field analytical and soil sampling equipment to help define areas of subsurface contamination. For a description of the geophysical techniques and associated applications, refer to E & E's SOP for Surface Geophysical Techniques (see GEO 4.2).

7. Reagents

This procedures does not require the use of reagents except for decontamination of equipment, as required. Refer to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15) and the Site-Specific Work Plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

1. The preparation of a Health and Safety Plan is required prior to any sampling. The plan must be approved and signed by the Corporate Health and Safety Officer or his/her designee (i.e., the Regional Safety Coordinator).

2. Prepare a Sampling Plan to meet the data quality objectives of the project in accordance with contract requirements. Review available background information (i.e., topographic maps, soil survey maps, geologic maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling method to be employed, and the type and amounts of equipment and supplies required.

3. Obtain necessary sampling and monitoring equipment (see Section 6), decontaminate or preclean the equipment, and ensure that it is in working order.

4. Contact the delivery service to confirm the ability to ship all equipment and samples. Determine whether shipping restrictions exist.

5. Prepare schedules and coordinate with staff, clients, and regulatory agencies, if appropriate.

8.2 Field Preparation

1. Identify local suppliers of sampling expendables (e.g., ice and plastic bags) and overnight delivery services (e.g., Federal Express).

2. Decontaminate or preclean all equipment before soil sampling, as described in E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15), or as deemed necessary.

3. A general site survey should be performed prior to site entry in accordance with the Health and Safety Plan, followed by a site safety meeting.

4. Identify and stake all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or field team prior to soil sampling.

8.3 Representative Sample Collection

The objective of representative sampling is to ensure that a sample or group of samples adequately reflects site conditions.

8.3.1 Sampling Approaches

It is important to select an appropriate sampling approach for accurate characterization of site conditions. Each approach is defined below. Table 8-1 summarizes the following sampling approaches and ranks them from most to least suitable based on the sampling objective.

8.3.1.1 Judgmental Sampling

Judgmental sampling is based on the subjective selection of sampling locations relative to historical site information, on-site investigation (site walk-over), etc. There is no randomization associated with this sampling approach because samples are collected primarily at areas of suspected highest contaminant concentrations. Therefore, any statistical calculations based on the sampling results would be unfairly biased.

Table 8-1 Representative Sampling Approach Comparison

Sampling Objective	Judgmental	Random	Stratified Random	Systematic Grid	Systematic Random	Search	Transect
Establish Threat	1	4	3	2[a]	3	3	2
Identify Sources	1	4	2	2[a]	3	2	3
Delineate Extent of Contamination	4	3	3	1[b]	1	1	1
Evaluate Treatment and Disposal Options	3	3	1	2	2	4	2
Confirm Cleanup	4	1[c]	3	1[b]	1	1	1[c]

1 Preferred approach.
2 Acceptable approach.
3 Moderately acceptable approach.
4 Least acceptable approach.
a Should be used with field analytical screening.
b Preferred only where known trends are present.
c Allows for statistical support of cleanup verification if sampling over entire site.

8.3.1.2 Random Sampling

Random sampling involves the arbitrary collection of samples within a defined area. Refer to EPA 1984 and EPA 1989 for a random number table and guidelines on selecting sample coordinates. The arbitrary selection of sample locations requires each sample location to be chosen independently so that results in all locations within the area of concern have an equal chance of being selected. To facilitate statistical probabilities of contaminant concentration, the area of concern must be homogeneous with respect to the parameters being monitored. Thus, the higher the degree of heterogeneity, the less the random sampling approach will reflect site conditions (see Figure 8-1).

8.3.1.3 Stratified Random Sampling

Stratified random sampling relies primarily on historical information and prior analytical results to divide the area of concern into smaller sampling areas, or "strata." Strata can be defined by several factors, including sampling depth, contaminant concentration levels, and contaminant source areas. Sampling locations should be selected within a strata using random selection procedures (see Figure 8-2).

8.3.1.4 Systematic Grid Sampling

Systematic grid sampling involves the division of the area of concern into smaller sampling areas using a square or triangular grid. Samples are then collected from the intersections of the grid lines, or "nodes." The origin and direction for placement of the grid should be selected by using an initial random point. The distance between nodes is dependent upon the size of the area of concern and the number of samples to be collected (see Figure 8-3).

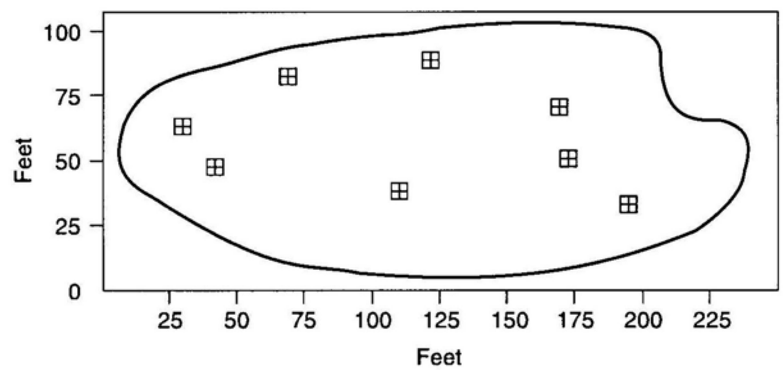


Figure 8-1 Random Sampling**

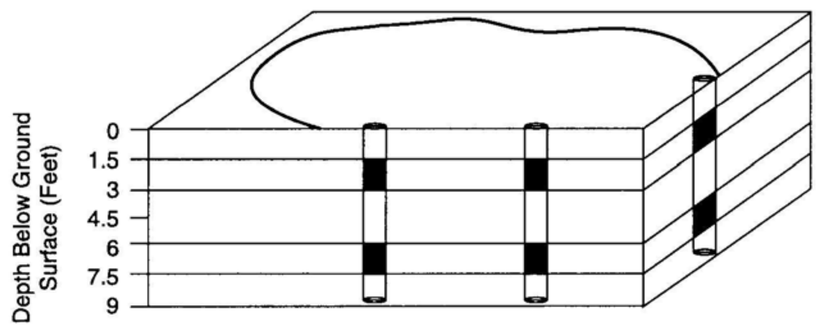


Figure 8-2 Stratified Random Sampling

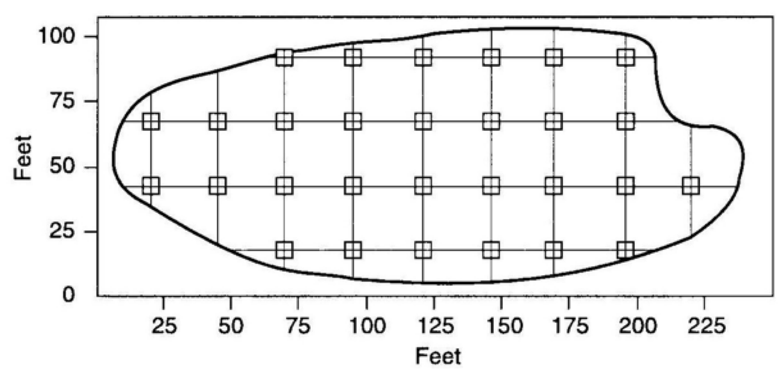
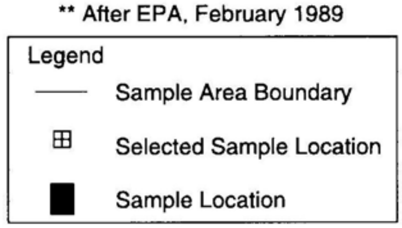


Figure 8-3 Systematic Grid Sampling**

** After EPA, February 1989



8.3.1.5 Systematic Random Sampling

Systematic random sampling involves dividing the area of concern into smaller sampling areas as described in Section 8.3.1.4. Samples are collected within each grid cell using random selection procedures (see Figure 8-4).

8.3.1.6 Biased-Search Sampling

Search sampling utilizes a systematic grid or systematic random sampling approach to define areas where contaminants exceed cleanup standards (i.e., hot spots). The distance between the grid lines and number of samples to be collected are dependent upon the acceptable level of error (i.e., the chance of missing a hot spot). This sampling approach requires that assumptions be made regarding the size, shape, and depth of hot spots (see Figure 8-5).

8.3.1.7 Transect Sampling

Transect sampling involves establishing one or more transect lines, parallel or nonparallel, across the area of concern. If the lines are parallel, this sampling approach is similar to systematic grid sampling. The advantage of transect sampling over systematic grid sampling is the relative ease of establishing and relocating transect lines as opposed to an entire grid. Samples are collected at regular intervals along the transect line at the surface and/or at a specified depth(s). The distance between the sample locations is determined by the length of the line and the number of samples to be collected (see Figure 8-6).

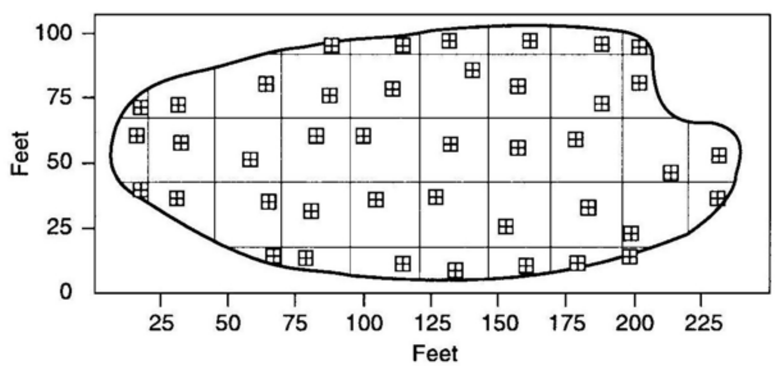


Figure 8-4 Systematic Random Sampling

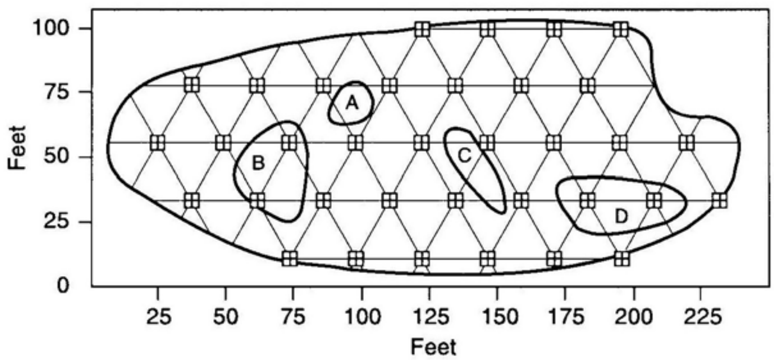


Figure 8-5 Search Sampling

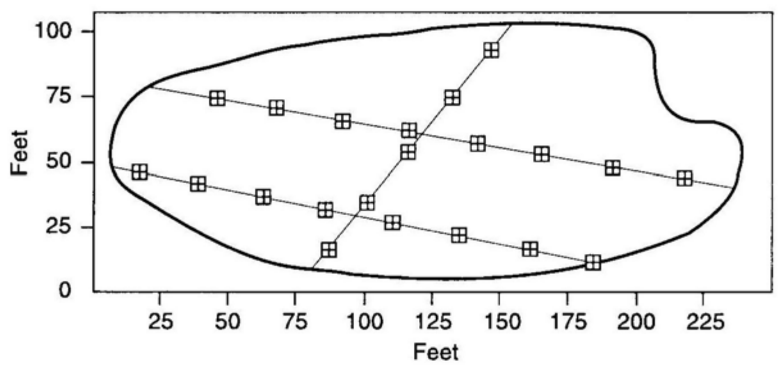
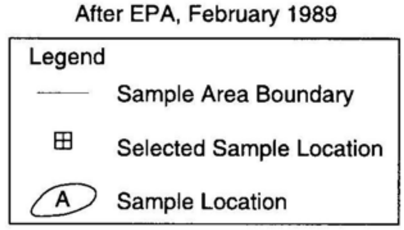


Figure 8-6 Transect Sampling

After EPA, February 1989



8.3.2 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, spoons, shovels, and scoops. The surface material can be removed to the required depth with this equipment; stainless-steel or plastic scoops can then be used to collect the sample.

This method can be used in most soil types, but is limited to sampling near-surface areas. Accurate, representative samples can be collected with this procedure, depending on the care and precision demonstrated by the sampling technician. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required (e.g., for volatile organic analyses [VOAs]). A stainless-steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials, as is common with garden implements such as potting trowels.

Soil samples are collected using the following procedure:

1. Carefully remove the top layer of soil to the desired sample depth with a precleaned spade;

2. Using a precleaned, stainless-steel scoop, spoon, trowel, or plastic spoon, remove and discard the thin layer of soil from the area that came into contact with the shovel;

3. Transfer the sample into an appropriate container using a stainless-steel or plastic lab spoon or equivalent. If composite samples are to be collected, place the soil sample in a stainless-steel or plastic bucket and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Place the soil samples into labeled containers. **(Caution: Never composite VOA samples)**;

4. VOA samples should be collected directly from the bottom of the hole before mixing the sample to minimize volatilization of contaminants;

5. Check to ensure that the VOA vial Teflon liner is present in the cap, if required. Fill the VOA vial fully to the top to reduce headspace. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time;

6. Ensure that a sufficient sample size has been collected for the desired analysis, as specified in the Sampling Plan;

7. Decontaminate equipment between samples according to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15); and

8. Fill in the hole and replace grass turf, if necessary.

QA/QC samples should be collected as specified, according to the Work Plan.

8.3.3 Sampling at Depth with Augers and Thin-Walled Tube Samplers

This system consists of an auger, a series of extensions, a T-handle, and a thin-walled tube. The auger is used to bore a hole to a desired sampling depth and is then withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the soil to the completion depth. The core is then withdrawn and the sample is collected.

Several augers are available, including bucket type, continuous-flight (screw), and post-hole augers. Because they provide a large volume of sample in a short time, bucket types are better for direct sample recovery. When continuous-flight augers are used, the sample can be collected directly off the flights, usually at 5-foot intervals. The continuous-flight augers are satisfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection because they are designed to cut through fibrous, rooted, swampy soil.

The following procedures will be used for collecting soil samples with the hand auger:

1. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, and litter). It may be advisable to remove the first 3 to 6 inches of surface soil from an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated soils onto a canvas or plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from the boring. When sampling directly from the auger, collect the sample after the auger is removed from the boring and proceed to Step 11.

5. A precleaned stainless-steel auger sleeve can also be used to collect a sample. After reaching the desired sampling depth, remove the auger and place the sleeve inside the auger. Collect the sample with the auger. Remove the auger from the boring. The sample will be collected only from the sleeve. The soil from the auger tip should never be used for the sample.

6. Remove the auger tip from the dill rods and replace with a precleaned thin-walled tube sampler. Install the proper cutting tip.

7. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring, because the vibrations may cause the boring walls to collapse.

8. Remove the tube sampler and unscrew the drill rods.

9. Remove the cutting tip and core from the device.

10. Discard the top of the core (approximately 1 inch), because this represents material collected before penetration of the layer in question. Place the remaining core into the sample container.

11. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Place the sample bottle in a plastic bag and put on ice to keep the sample at 4°Celsius.

12. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

13. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Verify that the chain-of-custody form is correctly and completely filled out.

14. Record the time and date of sample collection, as well as a description of the sample, in the field logbook.

15. If another sample is to be collected in the sample hole, but at a greater depth, re-attach the auger bit to the drill and assembly, and follow Steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

16. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

17. Decontaminate the sampling equipment per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.3.4 Sampling at Depth with a Trier

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample material. Extraction of samples may require tilting of the containers.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. Transfer the sample into a suitable container with the aid of a spatula and brush.

5. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.

8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.

9. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

10. Decontaminate sampling equipment per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.3.5 Sampling at Depth with a Split-Spoon (Barrel) Sampler

The procedure for split-spoon sampling describes the extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be sampled to give a complete soil column, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extraction.

This sampling device may be used to collect information such as soil density. All work should be performed in accordance with American Society for Testing and Materials (ASTM) D 1586-84, *Penetration Test and Split Barrel Sampling of Soils*.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit on the bottom and the heavier head piece on top. Install a retaining cap in the head piece if necessary.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece because compression of the sample will result.

4. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.

5. Withdraw the split spoon and open by unscrewing the bit and head. If a split sample is desired, a clean stainless-steel knife should be used to divide the tube contents in half, lengthwise. This sampler is available in 2- and 3.5-inch diameters. The required sample volume may dictate the use of the larger barrel. If needed, stainless-steel or Teflon sleeves can be used inside the split-spoon. If sleeves removed from the split-spoon are capped immediately, volatilization of contaminants can be reduced. When split-spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved in 1974).

6. Cap the sample container, place in a double plastic bag, and attach the label and custody seal. Record all pertinent data in the field logbook and complete the sample analysis request form and chain-of-custody record before collecting the next sample.

7. If required, preserve or place the sample on ice.

8. Follow proper decontamination procedures and deliver samples to the laboratory for analysis.

8.3.6 Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soils when detailed examination of soil characteristics (horizontal, structure, color, etc.) is required. It is the least cost-effective sampling method because of the relatively high cost of backhoe operation.

1. Prior to any excavations with a backhoe, it is important to ensure that all sampling locations are clear of utility lines and poles (subsurface as well as above surface).

2. Using the backhoe, a trench is dug to approximately 3 feet in width and approximately 1 foot below the cleared sampling depth. Place removed or excavated soils on canvas or plastic sheets, if necessary. Trenches greater than 4 feet deep must be sloped or protected by a shoring system, as required by Occupational Safety and Health Administration (OSHA) regulations.

3. A shovel is used to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done.

4. Samples are collected using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose soil for sampling. Samples are removed and placed in an appropriate container.

5. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.

8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.

9. Abandon the hole according to applicable state regulations. Generally, excavated holes can simply be backfilled with the removed soil material.

10. Decontaminate sampling equipment, including the backhoe bucket, per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.4 Sample Preparation

In addition to sampling equipment, representative sample collection includes sample quantity, volume, preservation, and holding time (see Table 8-2). *Sample preparation* refers to all aspects of sample handling after collection. How a sample is prepared can affect its representativeness. For example, homogenizing can result in a loss of volatiles and is therefore inappropriate when volatile contaminants are the concern.

8.4.1 Sample Quantity and Volume

The volume and number of samples necessary for site characterization will vary according to the budget, project schedule, and sampling approach.

8.4.2 Sample Preservation and Holding Time

Sample preservation and holding times are as discussed in Section 4.

8.4.3 Removing Extraneous Material

Discard materials in a sample that are not relevant for site or sample characterization (e.g., glass, rocks, and leaves), because their presence may introduce an error in analytical procedures.

8.4.4 Homogenizing Samples

Homogenizing is the mixing of a sample to provide a uniform distribution of the contaminants. Proper homogenization ensures that the containerized samples are representative of the total soil sample collected. All samples to be composited or split should be homogenized after all aliquots have been combined. Do not homogenize samples for volatile compound analysis.

Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
SW-846								
VOA[e]	14 days from date sampled	14 days from date sampled	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HC1 until pH <2 and cool to 4° (ice in cooler)
Semi-VOA (BNAs)[e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
PCBs[d,e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 until pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	14 days from date sampled	14 days from date sampled	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH until pH >12 and cool to 4°C (ice in cooler)
Hexavalent chromium[a]	24 hours from time sampled	24 hours from time sampled	10 g	50 mL	8-oz. glass jar with Teflon-lined cap	125-mL polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Total Organic Carbon (TOC)[a]	NA	28 days from date sampled	5 g	10 mL	8-oz. glass jar with Teflon-lined cap	125-mL polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)
Total Organic Halides (TOX)	NA	7 days from date sampled	100 g	200 mL	8-oz. glass jar with Teflon-lined cap	1-L amber glass bottle	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)

Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
Total Recoverable Petroleum Hydrocarbons[e]	28 days from date sampled	28 days from date sampled	50 g	1 L	8-oz. glass jar with Teflon-lined cap	1-L amber glass bottle	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)
EPA-CLP								
VOA[e]	10 days from date received	10 days from date received	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HC1 until pH <2 and cool to 4°C (ice in cooler)
Semi-VOA (BNAs)[e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
PCBs[d,e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 to pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	12 days from date received	12 days from date received	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH to pH >12 and cool to 4°C (ice in cooler)
NYSDEC-CLP								
VOA[e]	7 days from date received	10 days from date received	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HC1 until pH <2 and cool to 4°C (ice in cooler)
Semi-VOA (BNAs)[e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)

Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
PCBs[d,e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 to pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	12 days from date received	12 days from date received	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH to pH >12 and cool to 4°C (ice in cooler)
EPA Water and Waste								
Total Dissolved Solids (TDS)	NA	7 days from date sampled	NA	200 mL	NA	1-L polyethylene bottle with polyethylene-lined cap	NA	Cool to 4°C (ice in cooler)

Note: All sample bottles will be prepared in accordance with EPA bottle-washing procedures. These procedures are incorporated in E & E's Laboratory and Field Personnel Chain-of-Custody Documentation and Quality Assurance/Quality Control Procedures Manual, July 1987.

[a] Technical requirements for sample holding times have been established for water matrices only. However, they are also suggested for use as guidelines in evaluating soil data.
[b] Holding time for GC/MS analysis is 7 days if samples are not preserved.
[c] Maximum holding time for mercury is 28 days from time sampled.
[d] If one container has already been collected for PCB analysis, then only one additional container need be collected for extractable organic, BNA, or pesticides/PCB analysis.
[e] Extra containers required for MS/MSD.

Key:

NA = Not applicable.

8.4.5 Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquots of the same volume or weight. Compositing samples provides an average concentration of contaminants over a certain number of sampling points. Compositing dilutes high-concentration aliquots; therefore, detection limits should be reduced accordingly. If the composite area is heterogeneous in concentration and its composite value is to be compared to a particular action level, then that action level must be divided by the total number of aliquots making up the composite for accurate determination of the detection limit.

8.4.6 Splitting Samples

Splitting samples (after preparation) is performed when multiple portions of the same samples are required to be analyzed separately. Fill the sample containers simultaneously with alternate spoonfuls of the homogenized sample (see Figure 8-7).

8.5 Post-Operations

8.5.1 Field

Decontaminate all equipment according to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.5.2 Office

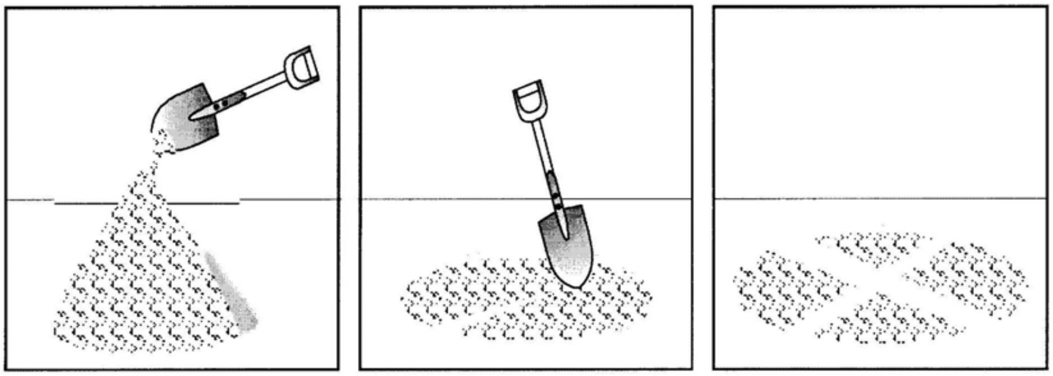
Organize field notes into a report format and transfer logging information to appropriate forms.

9. Calculations

There are no specific calculations required for these procedures.

10. Quality Assurance/Quality Control

The objective of QA/QC is to identify and implement methodologies that limit the introduction of error into sampling and analytical procedures.



Step 1:

- Cone Sample on hard, clean surface
- Mix by forming new cone

Step 2:

- Quarter after flattening cone

Step 3:

- Divide sample into quarters

Step 4:

- Remix opposite quarters
- Reform cone
- Repeat a minimum of 5 times

After: ASTM Standard C702-87

Figure 8-7 Quartering to Homogenized and Split Samples

10.1 Sampling Documentation

10.1.1 Soil Sample Label

All soil samples shall be documented in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16). The soil sample label is filled out prior to collecting the sample and should contain the following:

1. Site name or identification.
2. Sample location and identifier.
3. Date samples were collected in a day, month, year format (e.g., 03 Jan 88 for January 3, 1988).
4. Time of sample collection, using 24-hour clock in the hours:minutes format.
5. Sample depth interval. Units used for depths should be in feet and tenths of feet.
6. Preservatives used, if any.
7. Analysis required.

8. Sampling personnel.

9. Comments and other relevant observations (e.g., color, odor, sample technique).

10.1.2 Logbook

A bound field notebook will be maintained by field personnel to record daily activities, including sample collection and tracking information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete physical description of the soil sample, including texture, color (including notation of soil mottling), consistency, moisture content, cementation, and structure.

10.1.3 Chain of Custody

Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Refer to E & E's SOP for Sample Packaging and Shipping (see ENV 3.16) for directions on filling out this form.

10.2 Sampling Design

1. Sampling situations vary widely; thus, no universal sampling procedure can be recommended. However, a Sampling Plan should be implemented before any sampling operation is attempted, with attention paid to contaminant type and potential concentration variations.

2. Any of the sampling methods described here should allow a representative soil sample to be obtained, if the Sampling Plan is properly designed.

3. Consideration must also be given to the collection of a sample representative of all horizons present in the soil. Selection of the proper sampler will facilitate this procedure.

4. A stringent QA Project Plan should be outlined before any sampling operation is attempted. This should include, but not be limited to, properly cleaned samplers and sample containers, appropriate sample collection procedures, chain-of-custody procedures, and QA/QC samples.

11. Data Validation

The data generated will be reviewed according to the QA/QC considerations that are identified in Section 10.

11.1 Quality Assurance/Quality Control Samples

QA/QC samples are used to identify error due to sampling and/or analytical methodologies and chain-of-custody procedures.

11.1.1 Field Duplicates (Replicates)

Field duplicates are collected from one location and treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error for critical samples with contaminant concentrations near the action level.

11.1.2 Collocated Samples

Collocated samples are generally collected 1.5 to 3.0 feet away from selected field samples to determine both local soil and contaminant variations on site. These samples are used to evaluate site variation within the immediate vicinity of sample collection.

11.1.3 Background Samples

Background or "clean" samples are collected from an area upgradient from the contamination area and representative of the typical conditions. These samples provide a standard for comparison of on-site contaminant concentration levels.

11.1.4 Rinsate (Equipment) Blanks

Rinsate blanks are collected by pouring analyte-free water (i.e., laboratory de-ionized water) on decontaminated sampling equipment to test for residual contamination. These samples are used to assess potential cross contamination due to improper decontamination procedures.

11.1.5 Performance Evaluation Samples

Performance evaluation samples are generally prepared by a third party, using a quantity of analyte(s) known to the preparer but unknown to the laboratory. The percentage of analyte(s) identified in the sample is used to evaluate laboratory procedural error.

11.1.6 Matrix Spike/Matrix Spike Duplicates (MS/MSDs)

MS/MSD samples are spiked in the laboratory with a known quantity of analyte(s) to confirm percent recoveries. They are primarily used to check sample matrix interferences.

11.1.7 Field Blanks

Field blanks are prepared in the field with certified clean sand, soil, or water. These samples are used to evaluate contamination error associated with sampling methodology and laboratory procedures.

11.1.8 Trip Blanks

Trip blanks are prepared prior to going into the field using certified clean sand, soil, or water. These samples are used to assess error associated with sampling methodology and analytical procedures for volatile organics.

12. Health and Safety

12.1 Hazards Associated with On-Site Contaminants

Depending on site-specific contaminants, various protective programs must be implemented prior to soil sampling. The site Health and Safety Plan should be reviewed with specific emphasis placed on a protection program planned for direct-contact tasks. Standard safe operating practices should be followed, including minimization of contact with potential contaminants in both the vapor phase and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

- Particulate or Metals Contaminants
  - Avoid skin contact with, and ingestion of, soils and dusts.
  - Use protective gloves.

- Volatile Organic Contaminants
  - Pre-survey the site with an HNu 101 or OVA 128 prior to collecting soil samples.
  - If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

13. References

ASTM D 1586-67 (reapproved 1974), ASTM Committee on Standards, Philadelphia, PA.

ASTM D 1586-84, Penetration Test and Split Barrel Sampling of Soils.

Barth, D. S. and B. J. Mason, 1984, *Soil Sampling Quality Assurance User's Guide*, EPA-600/4-84-043.

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U.S. Environmental Protection Agency (EPA), 1984, *Characterization of Hazardous Waste Sites – A Methods Manual: Volume II, Available Sampling Methods*, (2nd ed.), 1984, EPA-600/4-84-076.

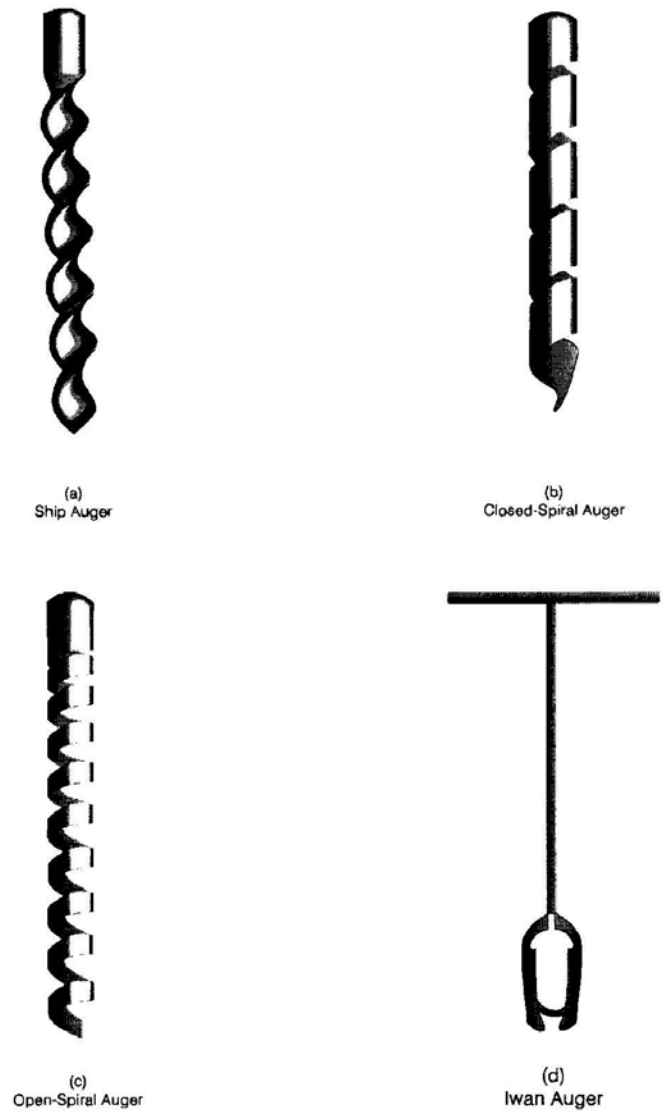
__________, 1991, *Removal Program Representative Sampling Guidance: Volume I – Soil*, (Interim Final), EPA-9360.4-10.

__________, 1984, *Characterization of Hazardous Waste Sites – A Methods Manual: Volume I, Site Investigations*, Section 7: Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA/600/4-84/075.

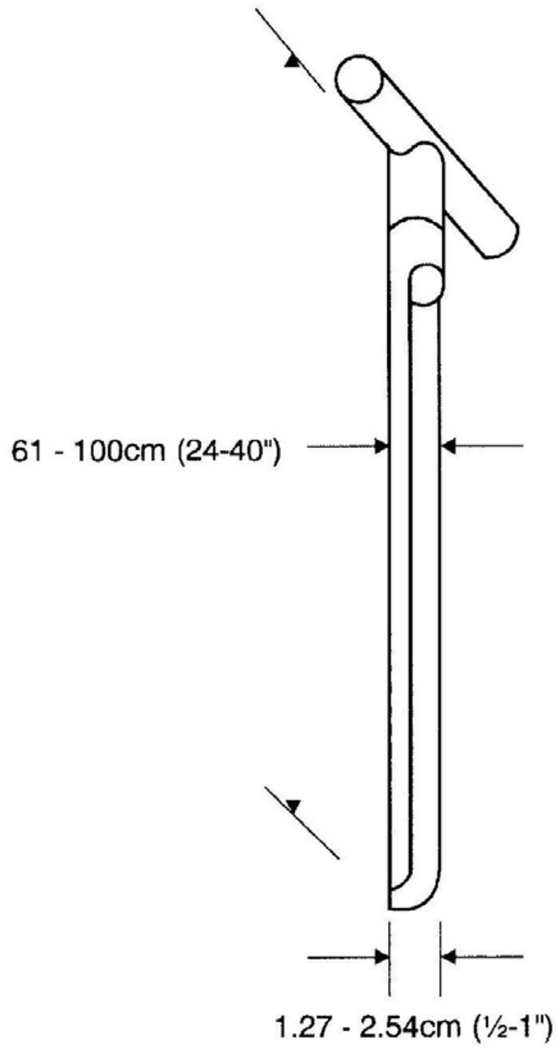
__________, February 1989, *Methods for Evaluating the Attainment of Cleanup Standards: Volume I, Soils and Solid Media*, EPA/230/02-89/042.

A SAMPLING AUGERS

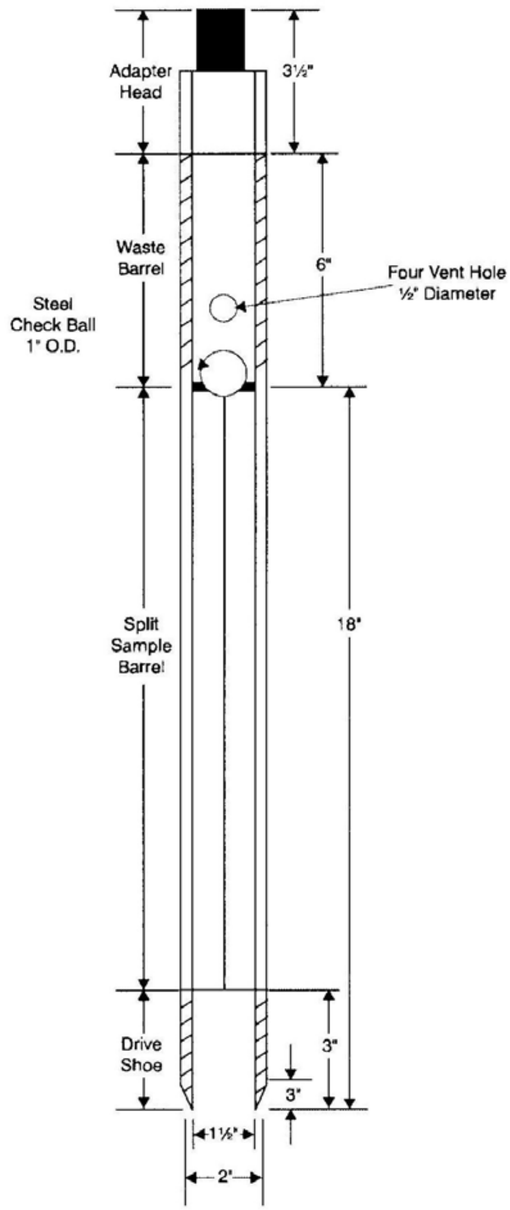
A. Sampling Augers



B SAMPLING TRIER



C SPLIT-SPOON SAMPLER



B Sample Plan Alteration Form

SAMPLE PLAN ALTERATION FORM

Project Name and Number: ____

____

____

Material to be Sampled: ____

____

____

Measurement Parameters: ____

____

____

Standard Procedure for Field Collection & Laboratory Analysis (cite references): ____________

____

____

____

Reason for Change in Field Procedure of Analytical Variation: ____________________

____

____

Variation from Field or Analytical Procedure: __________________________

____

____

Special Equipment, Materials, or Personnel Required: ______________________

____

____

____

CONTACT	APPROVED SIGNATURE	DATE
Initiator:		
START PL:		
EPA TM:		
EPA QA Officer:		

C Sample Forms

EPA

USEPA Contract Laboratory Program
Inorganic Traffic Report & Chain of Custody Record

1. Case No.:
DAS No.:

R

2. Region:	3. Date Shipped:	4. Chain of Custody Record	Sampler Signature:
Project Code:	Carrier Name:	Relinquished By: (Date/Time)	Received By: (Date/Time)
Account Code:	Airbill:	1)	
CERCLIS ID:	Shipped To:	2)	
Spill ID:		3)	
Site Name/State:		4)	
Project Leader:			
Action:			
Sampling Co.:			

5. INORGANIC SAMPLE No.	6. MATRIX/ SAMPLER	7. TYPE	8. ANALYSIS/ TURNAROUND	9. TAG No./ PRESERVATIVE/Bottles	10. STATION LOCATION	11. SAMPLE COLLECT DATE/TIME	12. ORGANIC SAMPLE No.	13. QC Type

14. Shipment for Case Complete?	15. Sample(s) to be used for laboratory QC:	16. Additional Sampler Signature(s):	17. Chain of Custody Seal Number:
18. Analysis Key:	**Type:** Comp, Grab (from Box 7)		19. Shipment Iced? ________

20. TR Number:

PR provides preliminary results. Requests for preliminary results will increase analytical costs.
Send Copy to: Sample Management Office, 2000 Edmund Halley Dr., Reston, VA 20191-3400 Phone 703/264-9348 Fax 703/264-9222

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USEPA Contract Laboratory Program
Organic Traffic Report & Chain of Custody Record

1. Case No.:
DAS No.:

R

2. Region:
Project Code:
Account Code:
CERCLIS ID:
Spill ID:
Site Name/State:
Project Leader:
Action:
Sampling Co.:

3. Date Shipped:
Carrier Name:
Airbill:
Shipped To:

4. Chain of Custody Record		Sampler Signature:	
Relinquished By:	(Date/Time)	Received By:	(Date/Time)
1)			
2)			
3)			
4)			

5. ORGANIC SAMPLE No.	6. MATRIX/ SAMPLER	7. TYPE	8. ANALYSIS/ TURNAROUND	9. TAG No./ PRESERVATIVE/Bottles	10. STATION LOCATION	11. SAMPLE COLLECT DATE/TIME	12. INORGANIC SAMPLE No.	13. QC Type

14. Shipment for Case Complete?
15. Sample(s) to be used for laboratory QC:
16. Additional Sampler Signature(s):
17. Chain of Custody Seal Number:
18. Analysis Key:
Type: Comp, Grab (from Box 7)
19. Shipment Iced? ____

20. TR Number:

PR provides preliminary results. Requests for preliminary results will increase analytical costs.
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10

CUSTODY SEAL

Date:
Signature:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10